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THE SPECIFIC HEATS OF CRYSTALLINE SOLIDS: PART I

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A CORRECT appreciation of the nature of the thermal agitation in a crystal is obviously of fundamental importance in the physics of the solid state. Closely related to it is the problem of evaluating the heat content of a crystalline solid as a function of the temperature. These topics have formed the subject of some recent studies by the present writer. From them has emerged a theory of the specific heats of crystalline solids which is both simple and comprehensive and which succeeds in establishing a quantitative relationship between the thermal properties and the spectroscopic behaviour of crystals and accounts for the facts of observation in both of these fields. It accordingly seems opportune to offer a connected review of the subject in which the basic principles are set forth as simply and clearly as possible.

2. Some General Considerations

A crystal is an assembly of great numbers of atoms (of the same or of several different species) in a three-dimensionally periodic array in space. Macroscopically regarded, a crystal of finite size is a single physical entity; and those problems concerning its physical behaviour in which the discrete atomic structure does not need to be specifically considered can be dealt with on that basis. But neither the evaluation of the thermal energy of the solid nor the determination of its spectroscopic behaviour is a problem of that nature. For, the discrete atomic structure of the solid is the very essence of both of these problems and it must therefore form the basis of any theoretical considerations regarding them. It is therefore a misconceived and irrational procedure to assume —as is done in the theories of Debye and Born—

the macroscopic crystal to be itself the oscillating unit whose modes and frequencies of vibration determine the thermal properties and the spectroscopic behaviour of the solid. While we have necessarily to reject such an approach as inadmissible, we are also precluded from assuming that the individual atoms in the crystal are the oscillators with which we are concerned. This is obvious, for the atoms in a crystal are linked together by forces of a physico-chemical nature and hence they cannot oscillate independently of each other. Thus, when both of these extreme suppositions are laid aside, we are left with the following questions requiring an answer. What are the oscillators which determine the thermal properties and the spectroscopic behaviour of a crystal? How are they to be enumerated, and in what manner are their modes and frequencies of vibration to be determined? The answers given to these questions stand at the very base of the problems now under consideration.

3. The Normal Modes of Vibration

The fundamental theorem in classical mechanics regarding the small vibrations of a system of connected particles, taken in conjunction with the three-dimensional periodicity of structure characteristic of the crystalline state, furnishes us with the key to the solution of our problem. The theorem referred to states that the possible vibrations of the system are superpositions of a set of normal modes, in each of which the particles of the system (in the present case, the atoms) vibrate with the same frequency and in the same or opposite phases. Hence, any mode of vibration which satisfies this description and which can be regarded as a characteristic property of the crystal must also satisfy the further criterion that it remains the same when the crystal is given a unit translation along any one of the three axes of its structure. This can obviously happen in two ways: following the unit translation, equivalent atoms in the adjacent cell retain their amplitudes and phases of vibration unaltered, or alternatively, while the amplitudes remain the same, the phases are all reversed. Thus, we have $2 \times 2 \times 2$ or 8 different possible situations. If there are p atoms in each unit cell of the crystal structure, each of the 8 possible situations give us $3p$ solutions of the equations of motion of the p atoms in the unit cell, in other words, indicates $3p$ normal modes of vibration with their respective frequencies which can be regarded as characteristic of the structure of the crystal. Thus, in all, we have $24p$ solutions of the equations of motion which may be divided into three groups: $(3p-3)$ normal modes in which equivalent atoms in adjacent cells oscillate with identical amplitudes and phases; $21p$ other normal modes in which the amplitudes of equivalent atoms in adjacent cells are the same but their phases alternate along one, two or all three of the axes of the crystal structure; and finally, the 3 excluded translations.

4. The Oscillators and Their Enumeration

We proceed to consider the physical significance of the results deduced and stated above. What they indicate is that we shall not be justified in identifying the groups of p atoms each which form the units of the crystal structure as the "oscillators" in specific heat theory, since their juxtaposition in the ordered structure of the crystal results in an eight-fold increase in the number of distinct frequencies of internal vibration which these groups of p atoms each would possess if isolated from each other. We have also to recognize the existence of additional modes of vibration within the crystal made possible by the translatory movements of the atomic groups as distinct from their internal vibrations. It is to be remarked, however, that the $(24p-3)$ normal modes of vibration with discrete frequencies indicated by the theory can be regarded as the *internal* modes of vibration of the groups of $8p$ atoms each to be found in volume elements whose dimensions are twice as large in each direction as those of the unit cells of the crystal structure. If the entire crystal encloses N unit cells, the number of groups of $8p$ atoms included in it would be $N/8$. Multiplying this by $(24p-3)$ which is the number of their internal modes of vibration, and adding to the product the number of degrees of the translatory freedom of movement of the same groups, we recover $3Np$, which is the total of the number of degrees of freedom of atomic movement in the crystal.

5. The Vibration Spectra of Crystals

Thus, the atomistic approach to specific heat theory leads us directly to a result which is of fundamental importance in relation to the spectroscopic behaviour of crystals, namely, that by far the largest proportion of the atomic degrees of freedom of movement in crystals is manifested in their vibration spectra as a set of discrete monochromatic frequencies $(24p-3)$ in number, p being the number of atoms in the unit cell, only the three omitted translations manifesting themselves in what may be designated as the "residual spectrum" comprising the lowest frequencies of vibration and having a different character which we shall

consider presently. The nature of the vibration spectrum of a crystal as stated above which is indicated by the theory might have been anticipated *a priori* on general grounds. For, a crystal comprises within itself an immense number of similar and similarly situated groups of atoms which would necessarily be of identical dynamical behaviour. Hence, the modes and frequencies of internal vibration of these groups would all be the same and would be a characteristic property of the crystal. The reason why we have $(24p-3)$ discrete frequencies and not $(3p-3)$ is also readily understood. The additional $21p$ frequencies arise because of the coupling of the oscillators located along each of the axes of the structure, an effect analogous to that observed in the simple case of two similar oscillators which when coupled to each other exhibit two distinct frequencies of vibration instead of only one.

We must now consider the nature of the "residual spectrum" briefly alluded to above. This spectrum embodies the oscillatory movements arising from the *translations* of volume elements of the crystal each containing $8p$ atoms; they may be described as *internal vibrations* in volume elements of still larger size and therefore having lower frequencies. The frequency ν of such a vibration can evidently range from a lower limit $\nu = 0$ to the upper limit $\nu = \nu_L$, ν_L being the lowest of the $(24p-3)$ discrete frequencies of atomic vibration. The manner in which the disposable $3N/8$ degrees of freedom would be distributed over this range of frequencies can be deduced by a very simple argument. The total number of volume elements of any specified dimensions included in the crystal, and therefore also the number of degrees of freedom represented by their *translations* would diminish in inverse proportion to the cube of their linear dimensions, while the frequencies of their *internal vibrations* would vary inversely as the first power of the same. Hence the number of degrees of freedom appearing in the residual spectrum in the range of frequencies between 0 and ν would be proportional to ν^3. By differentiation, we obtain the result that the number of degrees of freedom appearing between frequencies ν and $\nu + d\nu$, in other words, the number of oscillators in the crystal having frequencies in that range, would be $3N/8 \times 3\nu^2 d\nu/\nu_L^3$.

6. Quantisation of the Vibrational Energy

In his classic paper of 1907 introducing the quantum theory of specific heats, Einstein showed that the acceptance of his theory of light quanta inevitably leads to the conclusion that the energy of the mechanical vibration of elementary oscillators—such as the molecules of a gas or the structural units in a crystal—would also be related to their respective frequencies by the quantum rules. He also indicated a procedure by which the thermal energy of a crystal could be evaluated as a function of the temperature on the basis of the quantum hypothesis. He identified the thermal energy of the crystal with the energy of mechanical vibration of an immense number of *individual* oscillators distributed over its volume. It was assumed that these oscillators could be grouped into sets, each set comprising a great number of individual oscillators characterised by a common frequency of vibration. The total number of the oscillators of all kinds was taken to be equal to thrice the number of the atoms comprised in the crystal. The oscillators themselves were assumed to be harmonic and to occupy the various energy levels allowed by the quantum hypothesis for the particular frequency. The thermodynamic principle of Boltzmann was then introduced, leading to the result that the numbers of the oscillators occupying the various permitted levels are in the relative proportions indicated by that principle, and determined by the respective energies and by the temperature. The average energy of the oscillators in each of the sets was then evaluated. Summing up over all the oscillators in each of the sets and then over all the sets, Einstein obtained an explicit formula for the thermal energy of a crystal as a function of the temperature.

Einstein's ideas necessarily form the basis of any rational approach to the solution of the specific heat problem for crystals. For, they are based on an atomistic approach to the problem and effect a synthesis of the results of classical dynamics with the notions of the quantum theory and the basic principles of thermodynamics, in other words, of all the three disciplines which find a place in the problem. Einstein's formulation, however, had the weakness that he left unanswered three important questions: What precisely are the individual oscillators contemplated in the theory? How are they to be enumerated? How should their frequencies of vibration be determined? Also, to enable his theory to be applied in the particular case of diamond, Einstein assumed that the individual atoms in that crystal were themselves the oscillators contemplated in his theory. This was an oversimplification which resulted in discrediting Einstein's theory. For, that

assumption was theoretically unsustainable and it also led to values for the specific heats at low temperatures which were in disagreement with the experimental facts elicited by later investigations. It is not surprising in these circumstances that Einstein's approach to the specific heat problem was laid aside, and that other and totally different ways of approaching the same problem gained general acceptance.

The present approach to specific heat theory is in a sense a rehabilitation of Einstein's original ideas. It fills in the lacunæ left by him and we are thereby enabled to make use of Einstein's formulæ just as they stand for an evaluation of the thermal energy of the crystal. But, before we proceed to write down the expressions, it appears desirable to emphasize certain fundamental aspects of Einstein's theory which also find a place in the present approach to the subject. Einstein's application of Boltzmann's statistical—thermodynamical principle finds its logical justification in the fact that the crystal is regarded as an assembly of great numbers of similar oscillators capable of exchanging energy with each other and forming a system in thermodynamic equilibrium. The use of the principle implies that the energy of vibration of the individual oscillators of each sort exhibits fluctuations over the volume of the crystal both in space and in time, the magnitude of these fluctuations being naturally the greater, the higher the frequency of the oscillator considered. This picture of the thermal agitation in crystals is fundamentally in accord with the actual facts of crystal architecture as well as with the principles of thermodynamics, but it is very remote indeed from any ideas of its nature based on the notions of macroscopic physics.

Another feature of Einstein's theory which he himself stressed is the intimate relationship which it indicates between the thermal properties and the spectroscopic behaviour of crystals. The same relationship is also a feature of the present theory. But, the latter goes further than Einstein's, since it specifies the number of sets of oscillators which are the carriers of the thermal energy and also indicates the procedure by which their frequencies may be evaluated. Properties descriptive of the macroscopic behaviour of solids, *viz.*, their elastic constants, do not as such find a place in the present theory of the specific heats of crystals.

7. Evaluation of the Specific Heats of Crystals

Making use of the reasoning employed by Einstein, we obtain the following expression for the heat content of a volume of a crystal containing N unit cells of the crystal structure as a function of the temperature, namely

$$\frac{N}{8}\left[\sum_{i=1}^{24p-3}\frac{h\nu_i}{e^{h\nu_i/kT}-1}+\frac{3}{\nu_L^3}\cdot\int_0^{\nu_L}\frac{3h\nu^3 d\nu}{e^{h\nu/kT}-1}\right]$$

The numerical factor 1/8 appears in the expression because each oscillator comprises 8 unit cells of the crystal structure. On differentiating the expression with respect to T, we obtain the formula for the specific heat.

The following remarks may be made regarding the numerical evaluation of the expression given above. All the $(24p-3)$ frequencies would be distinct from each other only in the case of a completely anisotropic crystal. If any symmetry elements are present, the number of distinct frequencies would be naturally diminished, but the formula remains the same. Such reduction in the number of distinct frequencies would appear both in respect of the $(3p-3)$ frequencies in which both the amplitudes and the phases are the same in adjacent unit cells and in the $21p$ others in which the phases may be opposite, as already explained. As an illustration of these remarks, we may consider a case in which $p=2$ and the crystal belongs to the cubic class and its structure consists of two interpenetrating face-centred cubic lattices. The $(3p-3)$ distinct frequencies then reduce to a single triply degenerate frequency: the $21p$ or 42 other vibrations reduce to only eight distinct frequencies, the modes relating to all of which may be readily described in geometric terms connected with the structure of the crystal.

Since the first term in the expression for the thermal energy is a summation extended over $(24p-3)$ distinct modes of vibration, while the second represents the residual spectrum, it is evident that the latter would be of minor importance relatively to the first, especially in those cases where p is large, in other words when the crystal has a multi-atomic structure. The position is a little different when p is small, as for example, when p is equal to 1. The contribution from the second term would not then be altogether negligible in comparison with the first term. The second term also acquires some importance relatively to the first at very low temperatures. For, since the frequencies appearing in it are low, their contributions to the specific heat would survive when those due to the vibrations of the higher frequencies appearing in the first term have dropped out by reason of Boltzmann's principle.

GEOLOGY OF THE PAVAGAD HILL

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PAVAGAD HILL is an outlier of the Deccan Traps situated about 25 miles north-east of Baroda. Blanford[1] examined this hill in 1869 and noted that it was capped by a 'peculiar light purple argillaceous rock' which was later identified by Fermor[2] as rhyolite. Fermor[2] collected specimens of basalt, rhyolite, rhyolite-breccia, and pitchstone from the hill during a one-day visit and his descriptions are even now the only published detailed account of these rocks. Subsequently, a controversy started about the relationship of these rocks which has not yet been resolved.

Fermor found large boulders of rhyolite at different levels along the path leading to the top alternating with basalts, and came to the conclusion that the basalt and the rhyolite were interbedded. Beer[3] later gave a description of an ascending section of the hill in which he recorded the different levels where the different types of basalt and rhyolite were found.

Mathur and Dubey[4] later worked in this area, and concluded that the basalt and rhyolite lavas were not interbedded. They further recorded the occurrence of ultrabasic lavas which they considered intrusive into the basalt. In a separate communication Dubey[5] stated that the rhyolite and the basalt were not interbedded. According to him, while the ultrabasic magma followed the basic throwing out much basic tuff, the flows of rhyolite occurs on the surface at all levels which showed that they formed the last phase of igneous activity much later than the Deccan Trap. He proposed a Miocene age for the rhyolite from the determination of radioactivity and helium ratio. The rhyolite flows were further considered to have been erupted from vents and the topmost flow was regarded as an intrusive plug, surrounded as it is by thick deposits of agglomerates and ash.

The same views were reiterated by Mathur[6] in his Presidential Address to the Geology Section of the Indian Science Congress, 1934. Mathur also noted the occurrence of ultrabasic rocks closely associated with the ashes and tuffs and older than the rhyolite flows (p. 335). Fermor[7] got the view about the eruption of rhyolite from vents of Central type examined by Heron who reported that the top rhyolite represented a single horizontal flow.

The author of this note had an opportunity of examining the Pavagad area about a year back with a party of his senior students. In course of the survey of the main hill along the pilgrim route and a part of the base, and the adjoining smaller hills, definite evidence of interbedding, both horizontal and vertical, of two different types of lava was found. One of the lavas is basalt, but the other lava is purple-coloured, resembling a rhyolite, and produces purple and reddish soils. The colour of the lava varies from purple to reddish in more weathered outcrops and to a dark chocolate in many fresh outcrops. Along the path leading to the top from the Baroda-Shivrajpur Road, huge blocks of this lava are seen. There are also boulders of rhyolite. While many of them seem to have rolled down from higher levels, there are other exposures of rhyolite which appear to be *in situ*, judging by the parallelism of their joint planes and flow direction, six furlongs from the base. The latter is seen by the side of the first tank on the hill and in the two smaller hillocks to the south-east. In the smaller hill to the north of the road, this purple lava overlies bedded flows of anakaramite and is, in turn, overlain by basalt. Agglomerates in which fragments of basalt, sometimes olivine-bearing, are enclosed in the purple lava are common in different parts of the hill. The purple lava has many small included dark patches of tuff of the same composition, which are sometimes more vitreous than the main rock. It was evidently erupted with some explosive violence. There are dykes of an oceanite type of rock with many phenocrysts of olivine, and a few of pyroxene in a ground mass consisting of many grains of olivine, microlites of feldspars and some glass with iron ores, in the purple lava south of the road and another dyke of olivine basalt was noted in the smaller northern hill. From the broader relations of the two lavas—one basaltic and the other the purple-coloured one—the dykes seem to be of the type of composite dykes. The purple lava has a platy structure in some outcrops.

In its microscopic characters the purple rock has many similarities with *mugearites* which are associated with olivine basalt as composite lava flows in the Scottish Carboniferous province and as composite sills in Skye and Renfrewshire.[8] In fact, the mugearite lavas are interbedded with the olivine basalt lavas in several areas in Northern Ayrshire.[9] Mugearite has not so far been recorded from

India. The purple rocks show under the microscope a well-developed trachytic texture with small grains of pyroxene in between the microliths, and a few micro-phenocrysts of feldspars, often altered, pyroxene and olivine. There is plenty of magnetite granules and orange-coloured chlorophæite, besides secondary biotite round magnetite and zeolites. Fig. 1

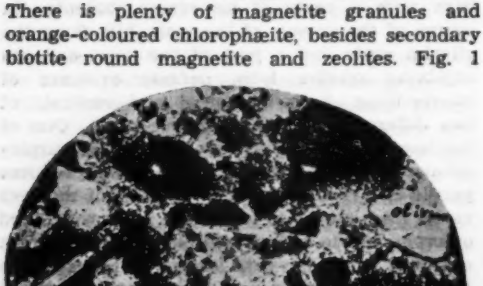

FIG. 1

shows an olivine micro-phenocryst on the right and an oligoclase lath on the left. There are many variations from these general characters. The feldspars are generally oligoclase as has been determined both from extinction angle and optic axial angle. In addition, the presence of orthoclase as individuals and as a mantle round the plagioclase, which is an important characteristic of mugearites, has been confirmed by staining with sodium cobaltinitrite and by the optic axial angles of micro-phenocrysts showing only Carlsbad twinning. The pyroxene micro-phenocrysts have a $2V$ varying from 55° to 57° indicating a diopsidic augite which is to be expected in alkaline basic rocks.

In the main Pavagad Hill, west of Budhyia Gate, about 1,100 ft. above the sea-level, below the rampart, is a section showing a series of purple-coloured lavas gently dipping to the north-west followed upwards by bedded basalt with well-marked columnar jointing. It was found that the lower flows consist of a trachyte with micro-phenocrysts of feldspars both sanidine and oligoclase, and granules of pyroxene with plenty of opaque reddish iron oxide and glass as shown in the second microphotograph while the basaltic rock is a porphyritic one with phenocrysts of bytownite in a ground mass with intersertal texture. The pyroxene of the basalt is almost identical with that of the trachyte and has a $2V$ of 55° to 57°. Fermor had noted the similarities between the pyroxene of the basalt and that of the rhyolite and the dacitic affinities of some of the rhyolites. Trachyte had not been recorded previously, but most of the flows of the lower slopes of the hill are of a trachytic (when olivine-free) or mugearitic (with olivine) type, the former with well-developed pyroxene crystals (Fig. 2). Dubey and Bajpai[11]

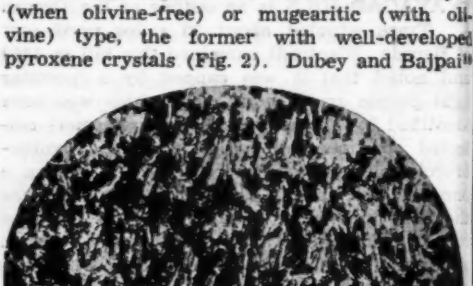

FIG. 2

in a paper on the radioactivity of the Deccan Traps described two porphyritic basalts, one containing phenocrysts of andesine and the other of oligoclase, the former at an altitude of 1,400 ft. and the latter at 1,600 ft., but in hand specimens they were indistinguishable from typical plateau basalts and so the oligoclase-bearing basalt was considered to be a more alkaline variety approaching andesite. It does not seem, therefore, that it was of the mugearite type found by this author although the possibility is there.

In the main hill, the first outcrop of normal basalt *in situ* was found about 1,000 ft. above the ground-level. Farther up is the interbedding of trachyte and basalt noted previously. Farther up is an extensive flow of porphyritic olivine basalt without feldspar phenocrysts and with pink iddingsite pseudomorphs after olivine, which extends along the eastern spur of the Pavagad Hill at the end of which stands the Bhadrakali Temple. But the temple itself stands on a flow of mugearite which is highly vesicular at this place. The mugearite forms a ridge. Besides, vertical impersistent sinuous bands of mugearite were also found in the basalt. Towards the main hill in the north-west, the next higher flow is of normal basalt (olivine-free and with feldspar phenocrysts). The temple is at a height of 1,734 ft. above sea-level while the normal basalt occurs about

2,000 ft. This is again followed by massive bedded flows of coarse-grained feldspar-phyric olivine basalt just below the wooden bridge above the trench which cuts off the main hill top. The feldspars show beautiful cruciform twinning. The olivine phenocrysts in all these flows have almost the same $2V$ (88° to 90°) indicating a high MgO content. There is no marked difference in the composition of the olivine and the pyroxene of the olivine-rich basalts of different levels. In the mugearites the olivine appears to be less magnesian. In both, the olivines are often zoned, particularly in the olivine-rich portions, and the pyroxenes are also zoned in some rocks.

On the last level of the Pavagad Hill, surrounding the turret of the top, are thick deposits of green ash beds containing phenocrysts of sanidine and albite, south-south-east of the temple at the top, and pink, brownish, whitish and variegated ash beds to the west and the north. The ash beds are followed by an extensive mass of rhyolite which forms the top. The flows show a slight basining near the top and the stratified ash beds form vertical bands. The rhyolite has very prominent vertical jointing which naturally suggested the idea of a plug to Dubey, surrounded as it is by ash beds, tuffs, agglomerates, and rhyolite-breccia, besides pitchstone and obsidian. The pitchstone forms a flow on the way to the ash beds and shows phenocrysts of albite, pyroxene and fayalite. There seems to be little doubt that the end of the magmatic period was marked by explosive type of eruption through localised vents and fissures in both the main Pavagad Hill and the south-eastern outlying hills.

In the smaller hill to the north of the road, a thick flow of basalt was found overlying the trachytic type of rock along the northern scarp on the face of a waterfall and a quarry.

The object of this note is to record the findings of certain new facts in their bare outline pending the working out of the mass of materials. In the Pavagad Hill are not only basalts and rhyolites, but also ankaramites, olivine-basalts, mugearites and trachytes. The olivine-basalt-mugearite-trachyte form a series in which there has been interbedding of flows of different kinds. The rhyolite seems to be younger as has been determined by Dubey from radioactivity, and overlies the former series. The relation of the rhyolite to the alkaline series still awaits investigation but Holmes' suggestion[11] about the association of basic and acid lavas in Central Complexes seems to be the probable explanation.

The above facts point to the existence of lavas of different composition, with more or less intratelluric crystallization, for eruption almost simultaneously or alternately as was supposed by Fermor, both for the Pavagad lavas and the Bushawal lavas. Geological literature provides well-known instances of similar association such as the lavas of the Scottish Carboniferous province, the islands of north-west Scotland, and the Hawaiian lavas described by MacDonald. MacDonald[12] has suggested a mechanism of such alternate eruptions from a common magmatic wedge in which some gravitative arrangement might have occurred with fractional differentiation, and fissures tapping different levels would bring to the surface lavas of different composition. West[13] found in Western Kathiawar an alternation between normal porphyritic basalt, porphyritic olivine-basalt, and oceanites and anakaramites in the lavas penetrated by deep boring.

A detailed study of the minerals of the different flows together with their composition in relation to the lavas and further field study are in progress, and the results will be published elsewhere in due course.

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ON THE PROCEDURE OF GROWING LARGE MONOCRYSTALS

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IN modern science and engineering the growing of monocrystals and their application plays an important part. Although crystals have been in practical use since many years because of their ultra-violet and infra-red power of transmission for optical purposes and for piezoelectrical and photoelectrical processes, the problem of growing them synthetically has only become acute when the store of natural crystals no longer met the ever-increasing requirements with regard to quantity and quality. This development commenced approximately 20 to 30 years ago.

By crystal growing, we understand the production of larger monocrystals in laboratories under constant conditions of growth. Monocrystals are crystalline bodies, the crystallographic axes of which have the same orientation at every point. Such crystals can be produced from any pure substances as well as from mixtures of these substances. Only after one had succeeded to produce large monocrystals, was it possible to examine many physical properties of metallic and non-metallic substances and to produce constructional elements for optical, piezoelectrical and electronic purposes.

As the growing of crystals is a little known specialised field, I wish to descirbe here the fundamental methods and a few applications of synthetic crystals.

In the growing of crystals, two basic processes are applied:

1. Growing from a solution,
2. Growing from the molten stage.

The hydrothermal synthesis for which high pressures and high temperatures are used in thick-walled steel vessels which can be closed (the so-called autoclaves), is still considered as a growing process from the solution, whereas the Verneuil process (flame melting process) represents the growing process from the molten stage. We are commencing with the growing of crystals from the solution. As mostly water is used as a solvent it is, of course, presumed that the substance to be crystallized readily dissolves in water without decomposing. If the solubility of the substance—as usually happens—depends on the temperature, *i.e.*, if it dissolves more at higher than at lower temperature, then a nucleus—a small monocrystal of the substance in question—can be placed in the solution which was saturated at a certain temperature. By slowly and continually lowering the temperature of the solution, a controlled deposit of the substance on to the nucleus can be brought about. On the other hand, if the solubility of the substance diminishes with rising temperature,—which occurs less frequently—the temperature of the solution must be slowly increased to effect a growth.

A process using an apparatus consisting of three containers is another variation of the method of growing crystals utilizing a drop in temperature. Whilst crystallisation takes place in one container, the two others are used for the saturation and temperature adjustment of the solution. Between the individual containers is a slight temperature gradient which is required for maintaining the crystallisation.

This process is especially suited to the manufacture of large monocrystals. In addition to the abovementioned processes of production, growing of crystals at a constant temperature with adjusted evaporation is also possible. A nucleus placed in the saturated solution is forced to grow by an initially low and subsequently increasing evaporation of the solvent conditioned by the continuous growth of the crystal.

With these methods of growing the surfaces of a crystal, the quickest growth may be 1 to 2·5 mm. daily, so that it may take weeks or months to obtain a crystal of the required dimensions. If clear, homogeneous and optically pure crystals are required, the temperature of the solution must be perfectly regulated during this time by a thermostat and a steady even mixing of the solution ensured, otherwise flaws—in the shape of clouding, turbidity and cracks—may occur in the growing crystal. The ends of the crystal which do not grow on to the wall of the container show well developed and even surfaces (see Illustration 1).

Illustration 1 shows examples of synthetic crystals grown according to the temperature falling method.

Examples from the solution-growth method are: alum which is used in optics, sodium potassium tartrate (Seignette), ammonium-dihydrogen phosphate (ADP), ethylene diamine tartrate (EDP), dipotassium tartrate (DKT), lithium sulphate, etc., used for piezoelectrical and electro-optical purposes. The hydrothermal growing of crystals has become of special importance for the synthetic production of

quartz crystals during the last 15 years, when it was highly developed particularly regarding the production technology. Here also the two fundamental methods of crystallisation at constant temperature, or with a temperature gradient, are used. Growing by means of a drop in temperature where very long autoclaves are used to maintain the temperature difference offers considerable advantages, and is used nowadays almost exclusively for the synthesis of quartz. We therefore wish to explain this process briefly. The base of the autoclave is fed with broken up natural quartz as a nutrient preparation whilst the orientated and uniaxial quartz nuclei crystals are fixed in the other part of the autoclave. A sufficient solubility required for the quartz to grow is then effected with increased temperature and pressure by a weakly alkaline solution. (At a volumetric ratio of 75 to 80% approx. 400° C. pressures approaching 1000 atm.) By differently heating the two ends of the autoclave a temperature gradient and thus also a difference in the concentration of the solution is achieved, i.e., by higher heating of the base part a greater saturation occurs in the nutrient substance than in the nuclei. The solution which in respect of the nuclei solution being oversaturated deposits the surplus, and the quartz nuclei grow. The varying concentration causes differences in the density, effecting a strong convection of the solution to make a continuous movement of the substance from the nutrient preparation to the nuclei possible.

The 2-chamber autoclaves are based on the same growing principle, but the dissolving and growing process is carried out in two different chambers, which are connected with each other.

Today it is already possible to produce quartz crystals of approx. 1 kilo weight in 2 to 3 months.

With substances which melt without decomposing or which are not water-soluble, the crystallisation is effected from the molten liquid. Even when a crystallisation from the solution as well as from the melt is possible, as for instance with rocksalt, the latter process is almost exclusively used because of the considerable saving of time.

It is a known fact that a melt cooling under normal circumstances solidifies in polycrystals. To achieve a monocrystalline growth there are two possibilities; in both cases, crystallisation commencing in one place and continuing through the whole melt. According to the first method evolved by Nacken and Kyropoules, a cooled down nucleus is planted into the overheated melt. For this purpose the melt is in a jar made of a suitable material standing in an electric oven. The growth commences from the nucleus acting as a cooling centre. The growing is controlled by slowly removing the crystal and by continuous lowering of the temperature of the melt up to the solidifying point. Thus, monocrystals of salt-like compounds the melting points of which range from 500 to 1,000° C. of approx. 15 kilo weight can be produced within a few days. It is characteristic of this method that the crystals have a rounded shape contrary to those grown from a solution (see Illustration 2).

In the process developed by Bridgman and Stockbarger, a cylindrical jar with a conical-shaped point is slowly lowered through two superimposed ovens. The temperature of the upper oven is kept constantly above the melting point of the substance, whilst the temperature of the lower oven is below the melting point. The oven combination thus has a vertical temperature gradient so that when continually lowering the jar in a certain place between the ovens, the crystallisation will commence on the top of the cone and expand from there. This method of growing has the advantage that substances with a high vapour pressure, or substances affected in the molten stage by the atmosphere, or the vapours of which are poisonous, all of which can be crystallised by working

Illustration 1: Synthetic crystal of ADP, sodium potassium tartrate and potash alum.

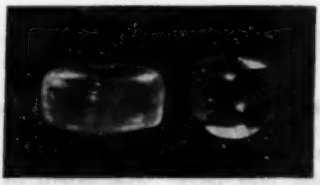

Illustration 2: Sodium chloride (crystal on the left) and lithium fluoride monocrystals grown according to the Kyropoules method.

Illustration 3: Sodium chloride (crystal on the left, lithium fluoride and KRS 5 crystal on the right) monocrystals grown according to the Stockbarger method.

in closed vessels or in a vacuum. (Illustration 3 shows crystals produced according to the Stockbarger method.)

Other processes (Stoeber) utilize the heat difference in such a way that initially the temperature on the lowest point of the vessel is below the melting point so that the first nuclei form there. By means of "nuclei selection" it is then possible to grow monocrystals by progressively lowering the temperature. These methods also allow for the production of large monocrystals, within a relatively short time. It is obvious that high demands must be placed on the temperature regulation, the course of the mechanical processes and the purity of the raw material.

The crystals produced from molten solutions —predominantly halides of alkali and alkaline earth metals—are used in infrared and ultraviolet spectroscopy as prisms, windows and bulbs. In infrared spectroscopy, *e.g.*, the crystals are used in a range where glass is not sufficiently transparent for testing rotation vibration spectra, and thus serve for ascertaining the structure of molecules. The methods of growing monocrystals of metal have become of immense technical importance, as their properties considerably deviate from those usually existing as polycrystalline aggregates. Similarly to the Nacken-Krypoules method, a cooled rod is dipped into the metal solution kept at a constant temperature. When this rod is slowly and evenly pulled out, monocrystalline coats of the solidifying metal are formed on it. Without going into details of its principles, mention should be made of the zonal melting process which was developed a few years ago and is used mainly for the purification of semiconductor substances, but can also be used in a modified way for the growing of monocrystals. It offers the special advantage of melting without a jar.

The crystallisation of substances with melting points above 1,500° C. is limited in the above-mentioned processes by the problem of ovens and jars. Verneuil published in 1891 a process according to which, except for minor changes, monocrystals are manufactured even today. The heating source is an oxyhydrogen flame. The substance is introduced into the oxygen current as a fine powder and falls on a clay stick on which it melts. Initially, a cluster of crystals forms from which by collective crystallisation a favoured nucleus grows to a pear-shaped monocrystal of approx. 5 cm. Corundum and spinel (melting points in the region of 2,000° C.) are examples of crystals produced in such a manner. Their use as precious stones and jewel bearings is well known. Production has so far advanced that thin orientated rods can be grown which can also be bent into loops for textile thread guides.

This process has also been successfully applied for growing silicone, but the flame melting heating was replaced by radiation or induction heating to make crystallisation in a vacuum or neutral gaseous atmosphere possible.—(Courtesy : *Jena Review*, No. 1, pp. 24-26.)

CONGRESS AND EXHIBITION AT FRANKFURT, 1958

THE European Congress of Chemical Engineering and the ACHEMA Congress, 1958, have been scheduled to take place at Frankfurt am Main from 31st May to 8th June 1958.

The scope and size of the forthcoming Congress will be considerably larger than the last meeting held in 1955 since the Congresses of the European Federation of Chemical Engineering and the European Federation of Corrosion which will take place within the framework of the European Congress of Chemical Engineering, will be organised with the co-operation of 58 technical and scientific societies from 17 different countries. During the same period the Gesellschaft Deutscher Chemiker is arranging a special meeting with a series of lectures and the DECHEMA will hold its Thirty-Second Annual Meeting.

Hundreds of firms from different countries are expected to take part in the Exhibition arranged at the Congress, with their exhibits on the latest developments in science and technology.

Further details can be had from : DECHEMA, Frankfurt am Main-7, Postfach (Germany).

ADVANCES IN GEOPHYSICS*

VOLUME III of *Advances in Geophysics*, edited by Dr. H. E. Landsberg, is particularly welcome at the present moment when we are on the threshold of the International Geophysical Year which will commence on July 1, 1957, and continue for 18 months.

The volume contains reviews by active, eminent geophysicists on the following seven subjects, all of which are of topical interest. Each review has appended to it a list of references to scientific papers and reports.

Arctic Island Research. By A. P. Crary.—In 1893-96, Nansen studied the oceanography and meteorology of the Arctic from his drifting frozen ship FRAM and demonstrated the great value of observations from such a moving station. The Soviets have made extensive investigations in this area both before and after World War II using drifting ships and floating ice-packs. The present article by Crary is a summary of the scientific work done since 1952 by the officers and scientific collaborators of the U.S.A. Air Force Cambridge Research Centre, from a base camp on a floating Ice Island T-3 which has an area of 43 square miles. The article includes studies in Arctic oceanography, meteorology, gravity, geomagnetism, geology and biology. Observations have been made over ice and under water. The report is in the nature of preliminary findings rather than completed scientific studies.

A bathymetric map of the Arctic, showing ocean depths including measurements made by the Soviets is incorporated. An interesting submarine feature is a long under-water ridge roughly parallel to Long. 135° E. to 45° W. and nearly passing through the pole, called Lomonosov Range by the Soviets.

The locations of the ice islands and their surface and sub-surface characteristics together with a study of the C 14 content of the dirt-deposits in the hollows afford evidence of their long history and of climatic trends. There are plant deposits corresponding to ages of about 6,000 years, 3,000 years and of 500-600 years. Dr. Crary states the tentative conclusion that "the present period is one of long-term warming which may lead to an open polar sea in a not too distant future".

There are three articles on Seismology and the Structure of the Earth, one by Professor Byerly of the University of California on "Sub-continental Structure", the second on "Heat Flow through the Deep Sea Floor" by Drs. E. C. Bullard, A. E. Maxwell and R. Revelle, and the third "On the Interior of the Earth", by Professor J. A. Jacobs of the University of Toronto.

The article by Byerly gives a critical account of the work done in different countries on the thickness of the crustal layer of the earth, and on the dispersion of surface waves. The estimated average thickness of the crustal layer over continents is 30-40 km. and there is a discontinuity beneath, which is called the Mohorovicic or M discontinuity. The speed of P waves above the discontinuity is 6-7 km./s. and below it, 7·5 to 8·4 km./s. In this study, Professor Byerly has brought together the evidence collected by seismologists in different continents from the recordings of natural earthquakes and also of waves from artificial explosions. The general conclusion is that the top crust of the earth is very varied in its constitution with perhaps two layers of varying thicknesses, but that below a depth of about 35 km., a homogeneous layer is met with.

In the article on "Heat Flow through the Deep Sea Floor", Professors Bullard, Maxwell and Revelle discuss the observations on heat flow made by the authors in the sediments of the ocean floors of the Atlantic and the Pacific. They find that although there is great variation in the heat flux from place to place, there is rough equality of oceanic and continental heat flows. The radio-active material in the granitic layer over continents is much more than in the basaltic crust of the ocean floor. This raises the question: How is the equality of heat flow maintained and what is the difference in the distribution of radio-active material in the earth's mantle under the ocean and under continents?

The article by Jacobs on the interior of the earth is a lucid and comprehensive survey of our present knowledge of this subject. Professor Jacobs has summarised the information about the composition, structure, thermal history and the magnetic field of the earth. He has also given some idea of the new knowledge that is coming out from a study of rock magnetism and on polar wanderings and possible reversals of the magnetic field of the earth in geological time. The seismological and magnetic evidence requires that the electrically conducting central part of the earth consists of an internal solid core surrounded by a fluid shell whose outer boundary is at a depth

* *Advances in Geophysics*, Vol. III. Edited by H. E. Landsberg. (The Academic Press, Inc., New York), 1957. Pp. x + 378. Price $ 8.80.

of 2,900 km. from the surface of the earth. The secular variations of the earth's magnetic field can be explained by a slipping back of the non-conducting solid outer mantle over the fluid core at an average rate of 2° in 10 years.

Dr. P. H. Jones and Dr. Skibitzke of the U.S.A. Geological Survey have given a very useful summary of modern methods used by field geophysicists to determine the depth, thickness, porosity, degree of saturation, etc., of aquifers and the chemical quality of the contained water. They have given a critical appraisal of the value of electric logging, temperature logging, bore-hole diameter logging, flow-meter logging and fluid conductivity logging. Radiation logging methods using natural radio-activity and absorption of neutrons from a Ra-Be source are also described.

There is an excellent article on the Optics of the Atmosphere by Z. Sekera dealing with the polarisation of skylight. It gives a good short account of Chandrasekhar's treatment of the basic problems of radiative transfer, and in particular, of the intensity and polarisation of skylight in a molecular atmosphere. As is well known, Chandrasekhar uses Stokes' polarisation parameters and takes account of multiple scattering and the earth's albedo.

Sekera has also described the experimental work on the intensity and polarisation of skylight which he and his collaborators are carrying out in California using a photomultiplier, polariser and rotating retardation plate. The California School is making a detailed study of the effects of atmospheric turbidity on the polarisation of skylight and its dispersion, and hopes to separate out the effect of large particles from that of molecules. A large amount of recent experimental material collected by the California School is summarised. Two outstanding problems in the Optics of the Atmosphere, one, the brightness and polarisation of the twilight sky in which the curvature of the earth has to be duly taken into account and another on the scattering of light in the near ultra-violet, where absorption due to ozone is important are very briefly discussed. Dr. J. Walton has done valuable work on the second problem.

The book appropriately concludes with an authoritative article by Dr. S. F. Singer on "Geophysical Research with Artificial Earth Satellites". This contains an account of the U.S.A. programme on artificial earth satellites during the I.G.Y. and discusses the scope of the problems that can be investigated with their help in the immediate future, and at later dates as techniques get improved. The satellite can be used as an inert object like the moon for geodetic measurements or as an instrument-carrying vehicle for studying different kinds of radiation and of particles which arrive at the earth from outside the atmosphere. The satellite project is a natural corollary to the use of rockets for the study of the high atmosphere. The latter has already yielded much fundamental information and these two new tools of research promise to yield further information about the time- and space-variations of the particle and wave radiations which reach the earth from the sun, interplanetary space and from outside the solar system.

The project *Vanguard* of the U.S.A. Department of Defence contemplates placing of satellites at an angle of 40° to the Equator and at a height of over 300 miles. The first satellites will be spheres of diameter 20" and carry a payload of 20 lb. They will measure infra-red radiation from the earth, extreme ultra-violet including Lyman-α radiation and X-rays from the sun, meteoritic erosion, magnetic fields and cosmic ray particles. Naini Tal in India will be one of the stations for watching and timing the movements of the satellites.

All the articles are written in a readable style and the book deserves wide circulation.

K. R. RAMANATHAN.

JOURNAL OF ULTRASTRUCTURE RESEARCH

MESSRS. ACADEMIC PRESS, INC., have announced the publication of a new periodical under this title. Its purpose is to assemble in one medium papers dealing with the ultrastructure of the elementary structural as well as functional components of cells and tissues. Papers on biological material analysed by means of electron microscopy, X-ray diffraction techniques, X-ray microscopy, polarisation optical analysis, and polarised infrared analysis will be acceptable as well as those describing techniques and instruments of importance for the development of ultrastructure research.

Manuscripts intended for publication should be sent to the Editorial Office, Department of Anatomy, Karolinska Institute, Stockholm-60, Sweden. The first volume consisting of four issues is priced at $ 15.00. Subscription orders should be sent to the publishers, The Academic Press, Inc., 111, Fifth Ave., New York-3, N.Y.

CANCER—A BIOLOGICAL APPROACH*

THE understanding and control of cancer is the most urgent problem of medicine today. A marked increase in the absolute mortality from cancer has been demonstrated in various regions of the world. The incidence of the cancer of the lung has shown a ten-fold rise during the past few decades, while Leukæmia is another malignant condition whose phenomenal increase during the last ten years is causing grave concern.

The intense research on cancer, so far, has been heavily biased in two practical directions, *viz.*, the early diagnosis of cancer and therapy by non-surgical means. Though these approaches are desirable from strictly utilitarian aspects, a clear picture of the process in terms of general biological concepts is an essential prerequisite for a rational study of carcinogenesis.

Cancer is growth of cells free from the normal control exercised by the organism as a whole. In the broad sense of the term, the change is a genetic one. Whether it represents a true somatic mutation, transfer of plasma genes, incorporation of a virus into a provirous state or some new concept yet to be formulated is a matter for investigation.

Though certain trends are discernible, the processes of normal control of cellular growth are still speculative. Effective controls vary greatly from one cell type to another. The pituitary control of the thyroid function provides one of the most clearly manifested feedback mechanisms in biological hormonal control. The first requirement for malignant growth is the loss of control mediated by physiological contact with adjacent cells. A significant proportion of the control of cellular reactions is intrinsic to the cells themselves. Cells of many types are constantly liberating 'self-markers' which are strongly suspected to be the specific agents of growth control and an interesting immunological theory of cancer has been built around this self-marker hypothesis. The loss of these markers is considered to be the primary determinant of malignancy.

The outstanding feature of recent work on transplantation has been the recognition that all populations of cancer cells are heterogeneous and are subject to the processes of mutation and selective survival. Mutation is as frequent in somatic cells as in germ cells. Development of malignancy is the result of successive mutations occurring in cells capable of continued proliferation. There is a strong tendency for virologists to consider the theory of cancer as a parasitic disease due to infection of cells by extrinsive viruses, as representing simply one rather potent means by which what is functionally equivalent to a somatic mutation can be produced.

Mutation, whether occurring spontaneously, or under the influence of mutagenic agents is regarded as a random occurrence. There is now, however, a fairly long list of chemicals which can be called mutagenics. Certain polycyclic aromatic hydrocarbons, azo dyes, epoxides, some ethyleneimenes and nitrogen mustards have all been shown to be carcinogenic in nature. An impressive amount of statistical evidence has shown cigarette smoking and atmospheric pollution associated with urbanisation and industrialisation as factors for the increase in lung cancer and the polycyclic hydrocarbon 3 : 4 benzpyrene content of these has been incriminated as the carcinogenic chemical.

But the greatest danger to mankind, today, is the global dissemination of radioactive material. Ionizing radiations, whether from X-rays, atomic explosions or entry of radioactive material into the body, play a very significant role as mutagenic agents. One important aspect of somatic mutation theory of cancer is the way in which it brings into the same focus the two important harmful effects of ionizing radiation, carcinogenesis and genetic damage. Just as genetic damage may only become manifest in distant generations, so somatic damage may have no immediate effect but may lead to an accumulation of stock of mutant cells, all, one or more steps nearer the malignant change. There is no doubt that every type of ionizing radiation has a measurable mutagenic power and the effect is cumulative. It is impossible to say that any dose of radiation is harmless. Fully established chronic effect of the atom bomb explosion over Japan has been the development of leukæmia in survivors years later.

Grave are the implications of the inevitible increase in the use of nuclear power, by the wide distribution of radioactive isotopes, by the global concentration of fission products from test explosions of nuclear and thermonuclear weapons and in the release of radioactive waste products disposal.

If somatic mutation is the key to the understanding of cancer, since there is no conceivable

* Based on the articles by Sir Macfarlene Burnet in the *British Medical Journal* 1957, April 6th and 13th.

way to induce a specific back-mutation, therapy along somatic-genetic lines is unthinkable. The chemotherapeutic approach based on physiological differences between the normal and the cancer cells suffers from the overwhelming intrinsic disadvantage that all anti-cancer drugs are also carcinogens.

There is little ground for optimism about cancer. Somatic cells, being what they are, the impact of the environment must inexorably lead to the accumulation of mutant cells and the development of cancer. Unless all sources of mutagenic stimulii are controlled, no hope of decreasing the incidence of cancer can be visualised in the near future.

M. SIRSI.

OBITUARY

PROF. BASANT KUMAR DAS

THE news of the death of Prof. B. K. Das on 6th April 1957, was received with deep regret by all who knew him. In the death of Prof. Das, India has lost a distinguished Zoologist of international repute. It is well known that Prof. Das was largely responsible for organising the Zoology Departments of the Calcutta and Hyderabad Universities.

Prof. Das was born on November 21, 1895, at Gangoor in Burdwan District. He was educated at the Government High School at Allahabad, and then at the Muir Central College, Allahabad, where he passed his M.Sc. in Zoology in 1918 standing first in the examination. In recognition of his merit and distinction in research he was awarded scholarships of the U.P. Government. In 1920 he was appointed Lecturer in Zoology at the Allahabad University, and, in 1923, he was awarded the U.P. State Scholarship for study abroad, and joined the Imperial College of Science and Technology, London, under the late Prof. E. W. MacBride, F.R.S. While at London University, he carried out researches on air-breathing fishes of India and obtained the D.Sc. Degree of the London University. On his return to India he was appointed Professor of Zoology of the Calcutta University. After working there for five years he joined the Osmania University in 1932, where he continued as Professor of Zoology till he retired from service. After retirement he was closely associated with the organisation of the Fisheries Department in Hyderabad. Professor Das's researches on air-breathing fishes has received worldwide recognition. It was for this work that he was awarded the Huxley Memorial Prize in 1931. In 1935, he represented India at the International Zoological Congress held in Lisbon and was elected as one of their Vice-Presidents. In 1940, he was President of the Zoological Section of the Indian Science Congress held at Madras.

Prof. Das took immense interest in his students, both in regard to their scientific training as well as their personal welfare and was a source of great inspiration to them. His death is a great personal loss to all his students. Even after retirement from the University service, Prof. Das rendered immense help to research workers by giving guidance and technical help. He leaves behind his wife, two daughters, two brothers and a number of friends to bemoan his loss.

B. S. BHIMACHAR.

INTERNATIONAL CONFERENCE ON RADIO-ISOTOPES IN SCIENTIFIC RESEARCH

FURTHER to our previous announcement (*Curr. Sci.*, 1957, p. 131), we now officially learn that the above Conference, organised by UNESCO, will be held in the premises of the New Faculty of Medicine, 45, Rue des Saints-Peres, Paris, from 9th to 20th September 1957.

English and French will be the working languages of the Conference and the UNESCO Secretariat will provide simultaneous interpretations in both the languages. Speeches made by Russian and Spanish participants of the Conference will also be interpreted in English and French. Papers presented and summaries of speeches made in languages other than English or French will be recorded in these two working languages only.

During this part of the year, when the weather will be usually fine in Paris, it would be difficult to find hostel accommodation unless reservations are made. Therefore, the participants are requested to correspond with UNESCO Radio-Isotopes Conference, 19 Avenue Kleber, Paris (16°), France, giving full particulars in block letters of their names, addresses, etc., so as to reach them on or before the 10th August 1957.

LETTERS TO THE EDITOR

THE FORMATION OF PHOTOSENSITIVE FILMS ON BRASS

In our previous communication[1] the formation of a photosensitive film on brass surface by immersing the specimen for three days in N/1000 tartaric acid and subsequent exposure to sunlight has been reported.

Similar photosensitive films have been obtained on specimens of alfa brass prepared as before by treatment with other reagents. The reagents employed were N/1000 solutions of malic acid, citric acid and acetic acid and ·5 N solutions of sodium bicarbonate and potassium tartrate respectively. The most efficient reagent for the promotion of the photosensitive film was a saturated solution of potassium persulphate. When a specimen is dipped in a saturated potassium persulphate solution for a few seconds, followed by dipping in water and subsequently exposed to sunlight for two to three seconds only, photosensitive film was obtained.

It is interesting to observe that the time of exposure to sunlight is considerably shortened if the specimen after treatment with the reagent is dipped in N/2 HCl for a second, followed by dipping in water and then exposed to sunlight. In some cases the photosensitive film is not obtained without the intervening hydrochloric acid treatment.

Similar photosensitive films were obtained on specimen of copper (electrolytic) heated in air, following Pilling and Bedworth,[2] in which the authors have concluded that the film is of cuprous oxide; however they do not state whether the films obtained by them were photosensitive. The chemical properties of the film have been reported before.[1] It may be concluded that the film is of cuprous oxide. Its

apparent insolubility in ammonia may be explained following U. R. Evans.[3] The cathodic reduction of the film (a method developed at Cambridge[4]), formed in malic acid, also gives one inflexion only suggesting the formation of one oxide of copper.

Preliminary observations have suggested that the sensitivity depends upon the formation of a film of critical thickness. This point however requires further investigation.

Our thanks are due to Ahmedabad Education Society for laboratory facilities and the Gujarat University for the grant of a research scholarship to one of us (M. N. Desai).

L. D. Arts College and M. G. Science Institute, Ahmedabad-9, *May* 9, 1957.

M. N. DESAI.
A. M. TRIVEDI.

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A NOTE ON THE PREPARATION OF URANIUM TETRAFLUORIDE

URANIUM TETRAFLUORIDE is generally prepared by hydrofluorination of uranium dioxide with hydrofluoric acid or anhydrous hydrogen fluoride.[1] It is also precipitated from aqueous solutions of uranyl fluoride, chloride or sulphate using stannous chloride and hydrofluoric acid.[2] Mention has also been made in the literature about electrolytic reduction of uranyl compounds to get UF_4. Many metal oxides can be converted to fluorides by reaction with fluorinated hydrocarbons.[3,4] The reaction of various uranium oxides with fluorinated hydrocarbons, chiefly freons, has been studied by Booth *et al.*[5] and the Brown University group,[6] who found that the physical characteristics of the UF_4 obtained by this procedure was different from that obtained by the hydrogen fluoride procedure. The UF_4 prepared with the help of freons was more desirable for certain purposes. In this laboratory studies have been made on the preparation of UF_4 by the reaction of freon-12 with the peroxy complex of uranium of the type $M_4U_4O_{15}F_6 \cdot XH_2O$ ($M = NH_4$, K, ½ Ba), instead of the oxides of uranium.

The ammonium form of the peroxy complex of uranium was prepared from crude sodium diuranate as reported earlier by the authors.[7] The oven-dried (110° C.) complex was heated in a current of freon-12 gas at 450-550° C. in a pyrex glass tube. During the reaction ammonium fluoride and other volatile halides like $FeCl_3$ sublimed off. The residue left behind in the reaction tube consisted of emerald green crystalline uranium tetrafluoride together with a small amount of soluble uranium halides. The fluoride was washed free of the soluble product with water and was then dried at 110° C. The yield of UF_4 was about 95%. Starting from crude sodium diuranate, containing U_3O_8—78·2%, Fe_2O_3—0·6%, SiO_2—0·62%, ThO_2—0·4%, rare earth oxides—1·7%, uranium fluoride analysing U—73·8%, F—23·5%, Fe—0·014%, ThO_2—nil, rare earth oxides— 4 p.p.m. has been obtained.

Details of this method have been worked out on 5 lb. scale and will be published elsewhere.

Thanks are due to Dr. Jagdish Shankar for his keen interest during the progress of this work, and to the Analytical Section for the chemical analysis.

N. S. KRISHNA PRASAD.
V. V. DADAPE.
Chemistry Division,
Atomic Energy Establishment, Trombay,
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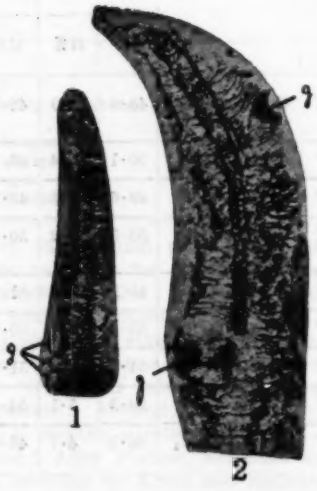
FOSSIL GALLS ON SOME JURASSIC CONIFER LEAVES

RAO in 1946[1] found some foreign bodies attached to the leaves of *Nipanioruha granthia*, a fossil conifer from the Jurassic of the Rajmahal Hills, Bihar, and described them as cylindrical or dome-shaped hollow bodies. He did not find any internal structure preserved in them and believed them to be of animal origin, possibly eggs or cocoons.

Recent examination of Jurassic conifers from Nipania near Amrapara in the Rajmahal Hills, has revealed that these foreign bodies are borne on fragmentary as well as *in situ* leaves of two species of *Nipanioruha*, *N. granthia* Rao emend. and *N. lanceolata* sp. nov. and also on the leaves of *Brachyphyllum nipanica* sp. nov.[2]

The leaves bearing them do not show any sign of decay and appear to be normal in structure (Figs. 1 and 2), while Rao found them on partly decayed leaves.



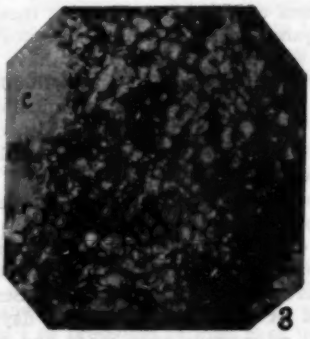


FIG. 1. A leaf of *Nipanioruha granthia* Rao showing four galls (*g*), × 30.

FIG. 2. A leaf of *Nipanioruha lanceolata* Sp. nov. showing two galls (*g*), cut in sections, × 30.

FIG. 3. A section through one of the galls showing a hallow cavity (*c*), surrounded by loosely packed cellular tissue, × 720.

These foreign bodies (Fig. 1), ovoid or kidney-shaped in form, slightly over 1 mm. long and about ¾ mm. broad, hollow from within, are made up of closely packed cellular tissue the cells of which are round to angular (Fig. 3). On the distal end of one of the foreign bodies there is noticed an aperture, probably an exit for the spores produced inside. The internal structure and the presence of an aperture preclude the possibility of there being a cocoon or an egg. These localised swellings are believed to be galls or tumours.

For a comparative study, free-hand sections were made of the galls on the leaves of modern *Ficus* sp., etc., and a striking anatomical similarity was found in both the fossil gall-like structures and the modern galls. Literature on modern galls[3] was consulted and the above identification confirmed.

The slides of the fossil material were later sent to Prof. M. S. Mani, Professor of Zoology and Entomology, St. John's College, Agra, for his opinion. In a personal communication, Professor Mani considers the foreign bodies as abnormal outgrowths of cells, *viz.*, galls. From the structural details he feels the galls were probably formed by a species of a mite. If this identification is correct as it appears to be, this is perhaps the first report of fossil galls from India. Fossil galls are, however, known from the Cretaceous and Post-Cretaceous horizons of the other countries but the structural details of the fossil galls are described for the first time.

My thanks are due to Prof. M. S. Mani for kindly examining the slides and confirming my observations.

Birbal Sahni Institute of Palæobotany,
Lucknow, *May* 31, 1957.

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SOME NEW β-PHENETHYLAMINES

β-PHENETHYLAMINE and its derivatives are well known for their sympathomimetic action which is modified by the presence of substituent groups. With a view to studying the effect of the latter in different positions in the aromatic ring on the physiological activity, a number of β-phenethylamines have been synthesised. The starting materials were the following aldehydes: (1) 2, 4-dimethoxy-6-methylbenzaldehyde, (2) 2, 4-diethoxy-6-methylbenzaldehyde, (3) 2-ethoxy-4-methoxy-6-methylbenzaldehyde, (4) 2, 6-dimethyl-4-methoxybenzaldehyde, (5) 2, 6-dimethyl-4-ethoxybenzaldehyde, (6) 2, 4-dimethyl-6-methoxybenzaldehyde, (7) 2, 4-dimethyl-6-ethoxybenzaldehyde, (8) 2-benzyloxy-3-methoxybenzaldehyde, (9) 2, 3,

No.	m.p. of nitro-styrene	Formula	Analysis				m.p. of amine picrate	Formula	Analysis			
			Found		Calculated				Found		Calculated	
			C%	H%	C%	H%			C%	H%	C%	H%
1	117°–18°	$C_{11}H_{13}O_4N$	59·1	5·6	59·2	5·8	219°–21° (*d*)	$C_{17}H_{20}O_9N_4$	48·0	5·0	48·1	4·7
2	115°–17°	$C_{13}H_{17}O_4N$	62·4	6·7	62·2	6·7	178°–80°	$C_{19}H_{24}O_9N_4$	50·1	5·4	50·4	5·3
3	135°–36°	$C_{12}H_{15}O_4N$	61·1	6·2	60·8	6·3	188°–89°	$C_{18}H_{22}O_9N_4$	49·6	5·3	49·3	5·0
4	115°–16°	$C_{11}H_{13}O_3N$	63·8	6·2	63·8	6·3	215°–16° (*d*)	$C_{17}H_{20}O_8N_4$	50·3	5·2	50·0	4·9
5	81°–82°	$C_{12}H_{15}O_3N$	65·4	7·1	65·2	6·8	185°–86°	$C_{18}H_{22}O_8N_4$	51·2	5·2	51·2	5·2
6	140°–41°	$C_{11}H_{13}O_3N$	64·0	6·1	63·8	6·3	188°–89°	$C_{17}H_{20}O_8N_4$	50·3	5·1	50·0	5·0
7	113°–14°	$C_{12}H_{15}O_3N$	64·9	6·5	65·2	6·8	173°–74°	$C_{18}H_{22}O_8N_4$	51·0	5·6	51·2	5·2
8	Oil	$C_{16}H_{15}O_4N$	..	..	..	..	143°–45°	$C_{23}H_{22}O_9N_4$	54·3	5·1	54·3	4·5
9	102°–03°	$C_{11}H_{13}O_5N$	55·1	5·6	55·2	5·4	158°–59°	$C_{17}H_{20}O_{10}N_4$	46·1	4·7	46·4	4·5

5-trimethoxybenzaldehyde. These were condensed with nitromethane[1] in the presence of acetic acid and ammonium acetate to give the corresponding β-nitrostyrenes. The latter were reduced with lithium aluminium hydride[2] to the β-phenethylamines isolated as their picrates.

These amines are being tested for their physiological activity, and a detailed account will be published elsewhere.

Dept. of Organic Chemistry, Institute of Science, Bombay-1, *June* 4, 1957.

J. R. Merchant.
A. J. Mountvala.

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BIOCHEMICAL STUDIES ON BUFFALO-BULL SEMEN

Seminal plasma exerts a distinct stimulating effect on the sperm motility, due partly to the "dilution effect" but mainly to the presence of specific substances present therein.[1]

The present investigation was undertaken with a view to estimate some of the important constituents of the seminal plasma of buffalo-bull and to trace any possible correlation between them and sperm activity as measured by "fructolysis index". Such biochemical studies on the semen of farm animals have assumed much importance in evolving suitable semen dilutors for use in artificial insemination. There is very little information in this respect in case of buffalo bull whose semen does not keep well in dilutors suitable for bull semen.

Six healthy buffalo bulls of Murrah breed, and approximately five years of age, were used for the experiment. They were kept under uniform management and feed, etc., throughout the entire experimental period. Semen was collected at regular intervals (7 days). But chemical estimations were made and fructolysis index of individual ejaculates measured in the twenty-eighth day samples. Two ejaculates from each bull were collected at an interval of 10 minutes every time and studied separately.

Within 2-3 minutes after collection, aliquots of whole semen were taken out for the estimation of fructose and total reducing substances. Then the samples (after the addition of few drops of chloroform) were suitably diluted, centrifuged and filtered. The filtrates were then kept in well-corked tubes in the ice chamber of a refrigerator after the addition of few more drops of chloroform, thus ensuring complete stoppage of any enzymic or any other

TABLE I

Chemical constituents	A Buffalo-bull		B Bull	
	Average mg./100 ml.	Range mg./100 ml.	Average mg./100 ml.	Range mg./100 ml.
Fructose ..	782	325–1423	540	280—770
Citric acid ..	489	322—820	720	340–1150
Total reducing substances ..	857	375–1480	..	..
Calcium ..	42	35— 62	34	24—45
Organic phosphorus ..	68	50— 99	73	..
Inorganic phosphorus ..	17	14— 25	9	..
Total nitrogen ..	485	381—625	756	..
Non-protein nitrogen ..	109	85—140	48	..

change in the seminal plasma for sufficiently long time required for the completion of all the estimations. The whole operation was finished within 15 minutes.

One hundred and eight samples were studied for sperm concentration and motility as measured by "fructolysis index" and were analysed for: *Fructose*: Method adopted by Mann,[2] using M/15 sodium citrate as buffer at pH 6·8. *Citric acid*: After Pucher, Sherman and Vickery[3] as modified by Krebs and Eggleston[4] and adopted by Humphrey and Mann.[5] *Total Reducing Substances*: After Hagedorn and Jensen[6] with suggested improvements by Folin and Malmros[7] and Kramer and Steiner[8]; *Calcium* was estimated by applying methods of Clark and Collip[9]; Roe and Kahn[10] and Berenblum and Chain[11]; *Organic and Inorganic Phosphorus*: Bernblum and Chain[11]; *Total and Non-Protein Nitrogen*: Folin and Farmer,[12] micro-kjeldahl method.

In all the methods herein adopted, a recovery of $100 \pm 5\%$ was always seen.

The averages and ranges of the various constituents studied are presented in Table I, Part A, and may be compared with those of bull semen[13] as presented in Part B of the same table. Sperm concentration, fructolysis index and concentration of the constituents of the individual samples and other details will be published later.

I am grateful to Dr. P. Bhattacharya for suggesting the problem and guidance.

My thanks are also due to Mr. S. N. Luktuke, Research Officer (Sterility), for his helpful suggestions in the execution of the work.

Indian Vet. Res. Inst., K. PAL.
Division of Animal Genetics,
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EFFECT OF TEMPERATURE ON THE LONGEVITY AND LIFE-HISTORY OF *MUSCA DOMESTICA NEBULO* FABR.

WITH a view to obtain information regarding the life-cycle of *Musca domestica nebulo* Fabr. throughout the year and to see whether temperature and relative humidity have any effect on its life-history and longevity of the adult fly, observations were made on a pure culture of the fly, reared by the author in Poona during 1955. A batch of 1,000 flies was kept under observation each month. The insects were bred in natural light. The eggs deposited by the females were transferred to a cage. The incubation period varied from 8 hours during summer months (April, May and June) to 20 hours during winter months (November, December, January and February). The larvæ were bred on a mixture of wheat bran, yeast and water. As they pupated, the pupæ were counted and

transferred to a separate cage, where the imagos emerged. The duration of the larval and pupal stages was noted. The adults were fed on crushed banana and milk. A daily record of maximum and minimum temperatures and relative humidity was kept from January 1955 upto December 1955.

The observations are recorded in Table I. It will be seen that during winter months

TABLE I

Month	Average larval stage in days	Average pupal stage in days	Average longevity of the adult in days	Mean temperature (½ max.+min.) °F.	Mean relative humidity %
1955—					
January ..	8	8	64	68	53
February ..	8	8	57	71	40
March ..	6	6	47	80	43
April ..	4	5	40	85	33
May ..	4	4	30	88	48
June ..	4	4	41	83	67
July ..	5	4	42	82	79
August ..	5	5	44	81	88
September ..	5	5	49	77	81
October ..	6	6	52	76	68
November ..	8	8	62	69	58
December ..	8	8	72	66	55

(November, December, January and February) the average duration of larval and pupal stages is 8 days, whereas during summer months

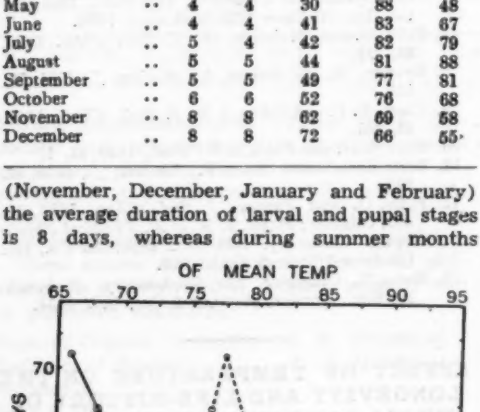

FIG. 1

(April, May and June), it is only 4 days. It will also be seen that during colder months the longevity of the adult is maximum, varying from 57 to 72 days, while during hot months it is minimum, varying from 30 to 41 days.

It will be found from Fig. 1 that longevity is highest (72 days) when the temperature is lowest (66° F.) and it is lowest (30 days) when the temperature is highest (88° F.). Thus longevity increases with decreasing temperature and decreases with increasing temperature. There is therefore a correlation between temperature and longevity of the adult. Temperature is inversely proportional to longevity and increasing temperature quickens the rate of development within limits.

As regards the relative humidity, it appears from Table I, that unlike temperature, it has no recognisable effect on longevity and life-history of the fly.

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October 19, 1956.

THE TETRAZOLIUM BROMIDE REDUCTION TEST IN ASSESSING THE QUALITY OF FISH*

TETRAZOLIUM salts have been used extensively in studies on the differentiation of tissues and dehydrogenase systems.[1-3] Laxminarayana and Iya[4] have studied the correlation between the bacterial count, and the time taken for the reduction of part of the tetrazolium bromide in assessing the quality of milk. At Torry Research Station, Aberdeen[5] test papers impregnated with tetrazolium salts were used for assessing the spoilage of cod and haddock stored in ice. The applicability of this test in assessing the quality of fish stored at 26-28° C. (laboratory temp.) by using modified procedure was studied and the results are presented in this note.

Absolutely fresh fish from shore-seine catches at Dhanushkodi were used in these experiments. To 2·5 ml. of the phosphate buffer of pH 7·2, 2 ml. of the muscle suspension (10 g. in 100 ml. of distilled-water) 0·5 ml. of triphenyl tetrazolium bromide were added, stoppered and incubated at 37° C. The tubes were occasionally shaken to promote uniform reaction. The time taken for the appearance of the red colour was recorded. The colour was extracted with normal butyl alcohol. The total volatile nitrogen, trimethyl amine and bacterial count of the fish muscle, were determined by the standard methods employed in this laboratory.[6]

The observations on the different types of fish like sardines, mackerel and *Lethrinus*

showed that the time taken for the initial appearance of red colour is proportional to the extent of fish spoilage when stored at laboratory temperatures. Several observations revealed that the colour was perceptible within 3 hr. when the fish passed the organoleptically fresh stage. In the case of spoilt fish it took less than 30 min. for the appearance of the red colour. In the second set of observations with iced fish the results are in good agreement with the organoleptic tests. *Lactarius* stored for 26 days with 41·06 mg.% of total volatile nitrogen and 9·00 mg.% of trimethyl amine nitrogen showed the red colour in 2 hrs. with a bacterial count over a million. Observations on *Caranx* stored in ice for 3 days showed red colour in 13 hrs. with a bacterial count of 100 colonies per gm. of the muscle with a low T.V.N. and T.M.A. values.

By allowing the reduction to proceed to a definite length of time from the onset of reduction it was noted that the intensity of colour was also related to the extent of spoilage. The presence of 1% sodium chloride was found to have an inhibitory effect on the time taken for the initial colour development. This point has a significant bearing on the application of this test in case of the salt-cured fish.

The observations indicate that the T.T.B. reduction test may prove useful in studies on fish spoilage. The time taken for the initial development of the colour seems to indicate the state of preservation of fish stored in ice when chemical data showed little indications. Further work is in progress for applying this test in routine examination of fish spoilage.

My thanks are due to Shri N. K. Velankar for his keen interest in the preparation of this note, and to Dr. N. K. Panikkar for his encouragement and guidance.

Central Marine Fisheries Res. Station, Mandapam Camp, *May* 29, 1957. P. V. KAMASASTRI.

* Published with the kind permission of the Chief Research Officer, Central Marine Fisheries Research Station, Mandapam Camp.

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THE PISTIL OF *OCHNA SQUARROSA* LINN.

THE occurrence of a completely hollow stylar canal opening freely to the outside in *Ochna squarrosa* has been reported in a brief abstract by the senior author (1947)[1] and the present paper describes in detail not only the structural features but also the course of the vascular bundles of the gynœcium.

The pistil of this species has a very deeply lobed ovary and a single gynobasic style, terminating in bifid stigmatic branches. The carpels, five to fifteen in number, are arranged in a whorl around the floral apex (Figs. 2 & 3),

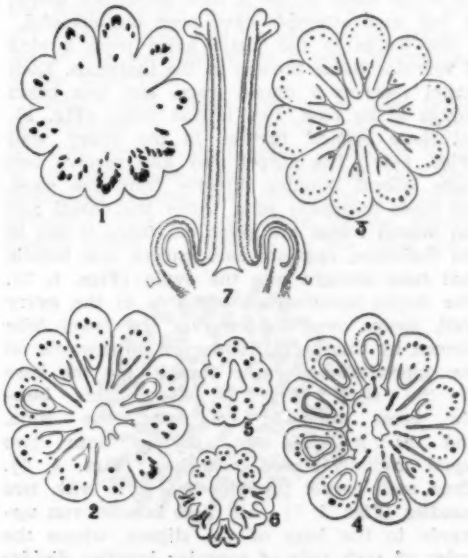

FIG. 1. T.S. passing through the base of the pistil.

FIGS. 2 & 3. T.S. of the ovary at two different levels in the lower part showing that the carpels are not completely free from one another.

FIG. 4. T.S. at a level near the base of the style.

FIG. 5. T.S. of the style.

FIG. 6. T.S. of the style near the stigmatic level.

FIG. 7. Diagrammatic median longitudinal section of the pistil.

and it is noteworthy that they are not so completely free from each other as sometimes described (Rendle, 1935).[2] For a very short distance near the base of the pistil in the central zone, the fusions of the margins of adjacent carpels are clearly seen (Fig. 3). This is in accord with the observations on the fruit of another species of this genus, namely, *Ochna multiflora* made recently by Baum (1951).[3] She

described that although an apocarpic appearance is marked in fruit development, the gynœcium is actually syncarpous. The hollow stylar canal in *Ochna squarrosa* appears to be far wider than what is shown in the figures of Baum given for *O. multiflora*. The canal opens freely to the outside without any hairy obstructions, as in *Butomopsis* reported by Johri (1937).[4] Although the pollen grains of *Ochna squarrosa* are much smaller than the width of the stylar canal they have not been actually seen within it, and possibly the pollen grains germinate only on the stigmatic surface and not within the stylar canal. Pollen grains have been artificially introduced by the authors into the stylar canal to see if they germinate therein, but such attempts have been unsuccessful.

The traces to the pistil arise from a ring of vascular tissue present in the thalamus. Each carpel receives a dorsal trace, and this bears almost at its base, two lateral veins (Fig. 1). All these branch further in the ovary wall (Figs. 1-4). The carpel may also receive two more lateral bundles directly from the stele, but these disappear soon. After the dorsal and the lateral traces are given off, there is left in the thalamus, opposite each carpel, one bundle that runs straight into the ovule (Figs. 1, 2). The dorsal bundle runs upwards in the ovary wall, passes over the crest of the ovary lobe formed by this carpel, and runs downwards on the opposite side of the carpel upto the base of the style (Fig. 7). Here, this bundle turns upwards to enter the style, and as it does so, divides into two equal radially-placed branches (Figs. 4, 7). Thus each carpel provides the style with two bundles (Figs. 5, 7). All these bundles run upwards to the base of the stigma, where the outer of each pair of vascular bundles divides into two, and these two branches run into a pair of stigmatic lobes (Figs. 6, 7). The inner vascular bundle runs to the base of the stigmatic lobes and disappears.

Dept. of Botany, V. S. Rao.
Ramnarain Ruia College, K. Gupte.
Matunga, Bombay-19,
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PHYSIOLOGICAL STUDIES IN THE BANANA "THELLACHAKRAKELI"

Refrigerated gas storage of fruits has been known for a long time and it has been realised that the particular temperature and gas concentration at which the fruits could be stored for the longest period of time has to be determined for each kind of fruit and also for the different varieties. Work has been in progress in this laboratory on the physiological changes taking place in the banana fruit variety "Thellachakrakeli" in storage at two different temperatures and in different carbon dioxide concentrations.

Studies on fully grown mature fruits of the banana variety locally known as "Thellachakrakeli" indicated that in storage at two different temperatures the carbon dioxide output of these fruits followed a similar pattern, i.e., a climacteric rise and senescent fall at the laboratory temperature of 30° C. (± 0·1° C.) and in the cold store at 10° C. (± 0·5° C.). The only difference, if any, was that the climacteric rise was prolonged in the latter with consequent delayed colour changes on the skin of the fruit.

The increase in acidity was steeper at the higher temperatures of 30° C. than at 10° C., the peak value being reached on the 19th day at the former and on the 27th day at the latter temperature. The acids detected in these ripe fruits by chromatograms were citric and malic.

Preliminary experiments on storage of these fruits in 10 and 20% carbon dioxide-air mixtures increased their storage life by 5 to 7 days and 9 to 10 days at the two temperatures of 30° C. and 10° C. and the less mature bunches reacted less beneficially in the excess carbon dioxide atmospheres than fully mature ones. Chromatograms obtained of fruits kept in different concentrations of carbon dioxide showed that the malic acid component increased with increasing concentrations of carbon dioxide and with the length of period in storage, while the other did not show such marked fluctuations.

Though refrigerated gas storage of fruits and vegetables is known for a long time the exact physiological mechanism involved is not fully understood. Kidd and West (1937) believe that the background for refrigerated gas storage is the combined effect of reduced oxygen and increased carbon dioxide concentration on the respiratory activity of the fruit which is lowered. Thornton (1933) observed a marked reduction in oxygen uptake by bananas and strawberries in carbon dioxide atmospheres of

30% or higher. Work carried out on other fruits by Gerhardt *et al.* (1941), also showed that fruits can be stored in excellent condition for short periods by storing in high concentrations of carbon dioxide and at a temperature of about 50° F. It has generally been made out that a high carbon dioxide environment depresses the respiratory activity of the fruit and thus prolongs the storage life of the fruit. It is also possible that when the fruits are stored in high carbon dioxide environments the carbon dioxide is absorbed in the dark and used as a metabolite for organic acid synthesis (Werkman and Wood, 1942; Thomas, 1947) and these organic acids follow the changes proposed in Krebs' cycle releasing the energy needed for respiratory activity slowly. Evidence collected in this investigation shows that there is considerable increase in malic acid with increase in carbon dioxide in the environment and with length of storage period in carbon dioxide. A detailed account of the investigations will be reported elsewhere.

Dept. of Botany, P. V. V. SESHAGIRI.
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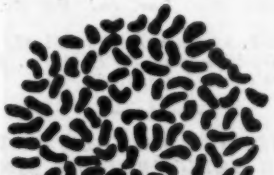
FUNCTIONING OF HAPLOID GAMETES IN THE CROSS *SACCHARUM OFFICINARUM* × *SACCHARUM SPONTANEUM*

CYTOGENETICAL researches on *Saccharum* during the last three or four decades have revealed certain interesting and significant features which are peculiar to sugarcane such as polyploidy, heterozygosity, chromosome elimination, parthenogenesis, functioning of unreduced gametes, etc. *Saccharum officinarum* has been observed to contribute unreduced gametes when used as a pistillate parent against *Saccharum spontaneum*—the wild species of sugarcane—and this has been considered to be a constant feature.[1-4]

During the current year, three seedlings were obtained by crossing *S. officinarum* var. Vellai ($2n = 80$) with *S. spontaneum* var. Uganda ($2n = 120$). The seedlings were studied for important morphological characters, stem epidermal pattern and brix (total solids in juice). In the matter of colour of stalk, thickness of stalk, number of rows of root-eyes and length and width of leaf, the hybrids were intermediate between the parents. The presence of ligular process in the hybrids was a character derived from the female parent. One of the hybrids flowered and the floral characters were noticed to be similar to those of Vellai, the pistillate parent. The stem epidermal pattern resembled the pollen parent in one seedling and the female parent in the other two. The brix per cent. in juice was the same as in Vellai in one of the seedlings while it was intermediate in the other two.

Acetic-orcein smear counts of the pollen mother-cells in the seedling G.5257, which flowered, revealed the presence of only 50 bodies in the metaphase plate indicating that only monoploid gametes have functioned in both the parents. This was confirmed by the somatic counts (Plate I) which in all the three seedlings showed $2n = 100$. As far as is known, this is the first record of reduced gametes functioning on the *S. officinarum* side when *S. spontaneum* is used as the staminate parent.



× 2,300.
PLATE 1

It may be mentioned that the variants of *S. spontaneum* used by previous workers in the hybridisation programme with *S. officinarum* were of the three groups $2n = 64$, 80 and 112. The variant used in the present case has $2n = 120$ chromosomes. The highest chromosome number so far recorded in *S. spontaneum* is $2n = 128$. The variants with $2n = 120$ to 128 differ markedly from the lower polyploid variants in the highly protogynous nature of the spikelets. Further studies in progress will show

whether the use of the variants with $2n = 120$ to 128 always results in monoploid gametes functioning on the *S. officinarum* side.

Parthasarathy[3] has suggested that "generally when the genetical or family relationship is near, reduced gametes function and when the relationship is more distant, the compatibility of the cross is presumably due to the functioning of the non-reduced gametes". On the basis of chromosome homology, a close relationship has been suggested between *S. officinarum* and *Sclerostachya, Narenga, Erianthus* and *S. robustum*.[5] The functioning of haploid gametes on the *S. officinarum* side in the present case would appear to suggest a close relationship between *S. officinarum* and *S. spontaneum* as well.

Further work is in progress.

Thanks are due to Shri N. L. Dutt for interest in the work and to Shri R. R. Panje for suggestions in the preparation of the note.

Sugarcane Breeding Inst., P. A. KANDASWAMY.
Lawley Road P.O., J. T. RAO.
Coimbatore, *April* 20, 1957.

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CHROMOSOME NUMBER IN THE GENUS *HELIOTROPIUM* LINN.

AHUJA AND NATARAJAN[1] have recently recorded the haploid chromosome number of *Heliotropium indicum* as thirty-two. Britton,[2] however, previously recorded it as $2n = 22$.

Investigations in the comparative anatomy, embryology and cytology of four species of *Heliotropium* are in progress in this laboratory for some time, the somatic and gametic counts of which are as follows:

	n	$2n$
1. *Heliotropium indicum* L.	11	22
2. *H. peruvianum* L.	9	18
3. *H. ovalifolium* Forsk.	16	32
4. *H. curassavicum* L.	14	28

The meiotic process in all the four plants studied appeared to be quite regular and normal bivalent formation has been observed. The study of the morphology of somatic chromosomes shows the presence of Sat- and secondary constricted chromosome. It is interesting to note in this connection that the chromosome number of *Heliotropium indicum* as observed during the course of this investigation corresponds with Britton's[2] findings. The plants studied by Ahuja and Natarajan,[1] therefore, appear to belong to a different cytologic race.

Britton[2] records twenty-six to be the diploid number for *Heliotropium curassavicum* whereas Schnack and Covas[3] report it to be twenty-eight. The present investigation corroborates the findings of the latter authors. Britton's determination of the chromosome number for *Heliotropium arborescens* (*H. peruvianum*) as $2n = 18$ finds support from the result of this investigation. The chromosome number of *Heliotropium ovalifolium* appears to be a new record.

From the available literature on the subject it appears that an aneuploid series occurs in the genus *Heliotropium*.

My thanks are due to Dr. I. Banerji under whose guidance and care this work has been carried out.

Dept. of Botany, PRADYOT K. PAL.
Calcutta University,
Calcutta-19, *June* 4, 1957.

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2 Britton, D. M., *Brittonia*, 1951, **7**, 233.
*3. Schnack, B. and Covas, G., *Haumania*, 1947, **1**, 32.

* Not seen in original. Quoted from Darlington, C. D. and Wylie, A. P., *Chromosome Atlas of Flowering Plants*, 1955, George Allen & Unwin Ltd., London.

CHROMOSOME NUMBER OF SOME ASCLEPIADACEAE

IN a recent note by Ahuja and Natarajan (1957), it has been stated "the chromosome numbers of some common plants belonging to families like Asclepiadaceæ, Rubiaceæ, etc., have not been reported so far". So far as the family Asclepiadaceæ is concerned, the present author (1955) in a note published in this journal have recently recorded the chromosome numbers of five commonly occurring Asclepiadaceous plants. The present note gives some of the determinations made since then (Table I).

TABLE I

Species	Chromosome No. n	$2n$
Calotropis gigantea R. Br.	11	22
C. procera R. Br.	11	22
Dischidia rafflesiana Wall.	11	..
Dregea volubilis Benth.	11	22
Hemidesmus indicus R. Br.	..	22
Pergularia pallida W. & A.	11	22

It is interesting to note that the somatic chromosome numbers of *Calotropis gigantea* and *C. procera* agree with the determination of Ahuja and Natarajan; their gametic numbers were, however, not previously recorded.

Though the chromosomes are very small, the number and the morphology of the somatic chromosomes of different genera of the Asclepiadaceæ have been studied by prefixing the root tips in suitable chemicals like oxyquinoline, paradichlorobenzene, α-bromonaphthaline, coumarine, etc., and following the aceto-orcein squash technique. The gametic numbers, however, have been determined from permanent preparations.

It is proposed to present the karyotype analysis of the plants studied, soon. Mention may, however, be made that *Calotropis gigantea* shows a pair of secondary constricted chromosomes in addition to a pair of satellited chromosomes in its somatic complement.

My thanks are due to Dr. I. Banerji under whose guidance the work is being carried out and to the Ministry of Education, Government of India, for the award of a research scholarship.

Dept. of Botany, Calcutta University, *June* 13, 1957. INDUSEKHAR BISWAS.

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TANNIN IN ROOT TIP AS A PROBABLE GENERIC CHARACTER OF *ERIANTHUS*, MICHX

In the course of the routine work of fixing root-tips for determination of the chromosome numbers, it was noticed that root-tips of certain species of *Erianthus* when placed in Navashin's fixative (Langlet's modification) immediately turned black. When this test was applied to other species of *Erianthus* available at the Institute as also the species of *Saccharum*, *Sclerostachya* and *Narenga*, it was found that the root-tips of all species of *Erianthus* examined turned black, whereas those of the other three genera remained unaffected. Eighty varieties of *S. officinarum*, twenty of *S. spontaneum*, eight of *S. robustum*, ten of *S. barberi* and two of *S. sinense* and one each of *Sclerostachya fusca* and *Narenga porphyrocoma* were tested against six species of *Erianthus*, *viz.*, *E. ravennæ*, *E. munja*, *E. arundinaceous*, *E. hookerii*, *E. longisetosus* and *E. elephantinus*.

The blackening is confined to the active meristematic region of the roots. Transverse sections of the roots revealed that the blackening was caused by a precipitate in the cells in the cortical layer (Fig. 1). Microchemical tests showed that the blackening was caused by the presence of tannin which gets precipitated on reaction with chromic acid, one of the ingredients of the fixative. From this it appears that the occurrence of tannin in the root-tip is a character of at least six species of *Erianthus* and may very likely be of taxonomic value in the separation of the genus from the allied three genera. It confirms the distinctness of the genus *Erianthus* from *Saccharum* as suggested by Jeswiet[1] and Dutt and Rao.[2]

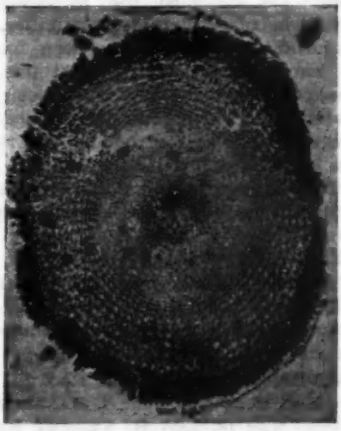

FIG. 1. *Erianthus* sp.

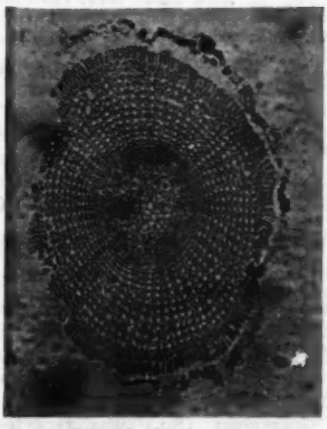

FIG. 2. *Saccharum* sp.

In recent years, many chemical factors have been found to be useful as indicators of taxonomic affinity and phylogenetic relationship. These characters are bound up with the basic physiological processes of the plants and are therefore particularly valuable in this direction. Mez[3] has classified the monocotyledons on the basis of protein compatibility. Oils, starch and fats in seeds have been found to have a taxonomic distribution.[4] At this Institute, the occurrence of starch has been found to be a character of specific importance.[5] The presence of tannin in the root-tip of *Erianthus* and its absence in the other three genera *Saccharum*, *Sclerostachya* and *Narenga* suggests that *Erianthus* is phylogenetically distinct from the other three.

Thanks are due to Shri N. L. Dutt for facilities, to Shri R. R. Panje for supply of material and helpful suggestions and to Shri R. Narasimhan for assistance in the microchemical tests and identification of the substance.

Sugarcane Breeding Inst., J. T. Rao.
Lawley Road Post, P. A. Kandaswamy.
Coimbatore, *May* 18, 1957. R. Krishna Kumari.

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STRIGA LUTEA AND COTTON

S. L. Sharma *et al.*[4] reporting on the parasitism of the three species of *Striga*, *viz.*, *S. euphrasioides*, *S. lutea* and *S. densiflora* stated that "the range of *S. euphrasioides* Benth., was both in natural and artificial conditions, the widest of all the three, followed by *S. lutea* Lour. and *S. densiflora* Benth., both in respect of Monocots and Dicots".

The *Gossypium* (Sp.) was reported to be resistant to all the three species of *Striga*, Luthra (1921).[1] It was stated by Bell and Dormer[2] (1932) that the exact mechanism of the inhibitory effect of cotton on the incidence and population of *Striga* in the succeeding *Sorghum* crop grown in highly infested fields needed further investigation. The experience of the local cultivators is that *Sorghum* grown after cotton has less attack of *Striga* parasite, while *Sorghum* grown after groundnut has severe attack, though they could not explain the reason.

During 1956-57, germination tests were conducted on *S. lutea* at Agricultural Research Station, Nandyal, under laboratory conditions making use of the method described by Narasimha Murthy *et al.*,[5] on crops normally grown in rotation with *Sorghum*. In a cylindrical glass trough, *Striga* seeds were set in between herbarium sheet cut to the size and wrapped round the inside wall of the glass pot, such that the *Striga* seeds could be seen through the glass-wall serving as a window from outside. Filling up the trough with sand, the host plants were grown in the glass pots and with the help of the root leachings the *Striga* seeds began to germinate, and the day-to-day progress of germination was watched in respect of the crop plants tried as hosts. The count of the *Striga* seeds germinated in each case is given below :

Table I

Sl. No.	Crop	Number germinated with seeds of		
		1954	1955	Total
1	Jonna (*Sorghum durra*)	33	9	42
2	Cotton (*Gossypium arboreum* var. *indicum*)	60	69	129
3	Cowpea (*Vigna unguiculata*)	19	2	21
4	Groundnut (*Arachis hypogea*)	1	1	2
5	Greengram (*Phaseolus aureus*)	Nil	Nil	Nil
6	Safflower (*Carthamus tinctorius*)	1	1	2

It is seen that in the tests of 1954 and 1955, the number of *Striga* seeds germinated is higher in cotton, even more than that in *Sorghum*. From this it is evident that root leachings of cotton has the stimulating principle that causes germination of *Striga* seeds. Yet, the experience is that no *Striga* plants come above ground in a crop of cotton either in field or pot culture. This shows that cotton, though by its root secretion could germinate *Striga* seeds, is unable to serve as a host. Kumar[3] has pointed out that *Striga* resistance in some of the *Sorghum* types is due to the structural differences in roots, and it is possible that for a similar reason cotton is unable to serve as a host.

The above results throw light on the inhibitory effect of cotton on the incidence of *Striga* in a *Sorghum* crop succeeding cotton. Incidentally the severity of incidence of *Striga* in a *Sorghum* crop following groundnut can be understood, since the stimulating effect of root leachings of groundnut is poor, the complete stock of *Striga* seed in the field is left un-

affected, to have its complete sway on the succeeding *Sorghum* crop.

Agric. Res. Station, Nandyal, *May* 16, 1957.

B. L. NARASIMHA MURTHY.
A. V. PARTHASARATHY.
M. SIVARAMAKRISHNAIAH.

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PRELIMINARY STUDIES ON BREEDING IN MAIZE FOR RESISTANCE TO THE TOP-SHOOT BORER

THE top-shoot borer, *Chilo zonellus* Swinhoe, is an insect pest attacking a wide range of host plants in India and is very destructive of maize, *juar* and sugarcane crops in this country. Not infrequently, entire crops of maize are destroyed by this pest. Insecticidal control, apart from being expensive, is often ineffective. Breeding of resistant strains constitutes the best way of combating the pest. No references are available in the literature on breeding for resistance to the top-shoot borer in India.

This pest is distinct from the European corn-borer, *Pyrausta nubilalis* (Hbn.), which has received considerable attention in the U.S.A. where several resistant inbred lines and hybrids have been evolved through field tests carried out under manual infestations (Hayes, Immer and Smith,[1] Patch and Everly,[2] Patch, Holbert and Everly,[3] Schlosberg and Baker[4] and Singh[5]). Preliminary studies conducted during the summer of 1956, at the Botany Division of the Indian Agricultural Research Institute, have shown that the techniques adopted in the U.S.A. for breeding for resistance to the European corn-borer are applicable, with some modifications, in similar work with the top-shoot borer.

The insects were reared in the laboratory on green maize stalks, for the production of egg clusters on a mass scale. Uniform infestation was brought about in the field on 3-4-week-old plants, by introducing the egg clusters in leaf-whorls of plants belonging to eight exotic and six indigenous inbred lines of maize. After 25-30 days of infestation, observations were recorded on the following characters: leaf injury, overall stalk injury and the number of stalk burrows made by the pest at maturity. Leaf injury was estimated by studying the extent of feeding of leaf by the larvæ; overall stalk injury indicated the damage caused to the growing point, the nodes and internodes; and the number of burrows in the stalk at maturity indicated approximately the number of larvæ present in the plant. The ratings of extent of injury was done by assigning grades. Leaf injury was graded from 1 (minimum) to 4 (maximum) and overall stalk injury was graded from 1 (minimum) to 5 (maximum).

The mean leaf injury ratings ranged from 1·4 to 3·8, the exotic inbred lines, T 202 and Tx61M showing the least amount of injury, *viz.*, 1·6 and 1·4 respectively. As regards stalk injury the ratings ranged between 1·8 and 4·8. In this respect also the exotic inbred T 202 was the least injured, the rating being 1·8. The other exotic inbred Tx61 M was second with respect to this character and showed a rating of 2·4. It was again remarkable that the exotic inbred T 202 showed the least amount of stalk burrows per plant, namely, 0·6. The other exotic inbred Tx61M was second with respect to this character and showed 2·0 mean number of stalk burrows per plant. The counts of stalk burrows per plant in other inbreds ranged from 3·5 to 14·0. The maximum measure of all-round resistance was thus manifested by T 202. The exotic inbred Tx61M was next in order of merit. Apart from these two inbreds, no differences were apparent as regards the behaviour of the indigenous inbred lines as a group as compared to that of the exotic inbreds.

Further work is underway, on an extensive scale, for assessing several inbred lines and hybrids of maize with regard to resistance to the top-shoot borer, under artificial infestation, with the ultimate object of evolving high-yielding, borer-resistant hybrids of maize.

Division of Botany, Indian Agric. Res. Inst., New Delhi, *May* 24, 1957.

S. M. SIKKA.
N. L. DHAWAN.
JOGINDER SINGH.

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SOLUBILISATION OF PHOSPHATES BY SOME COMMON SOIL BACTERIA

PIKOVSKAIA (1948) isolated from soils and phosphorites an organism, capable of actively decomposing calcium phosphate with formation of water-soluble phosphorus which he termed 'Bacterium P'. From soil cultures Menkina (1950) isolated a new strain of *B. megatharium* var. *phosphaticum* and a new variety of a species of *Serratia* var. *phosphaticum* which were capable of mineralising appreciable amounts of organic phosphorus. It is known that some of these strains are now being used in countries like Czechoslovakia, U.S.S.R., etc., for inoculation—apparently in rich soils, with the idea of bringing into solution sufficient amounts of phosphorus for nutrition of crops.

A strain (Fosfo 24) of a Phosphorbacterium was obtained from Czechoslovakia during 1956 and it was observed that in culture solutions in presence of inorganic and organic nitrogen, it brought into solution in varying amounts, phosphorus from insoluble organic and inorganic phosphates. It was found to be an aerobic bacterium, capable of functioning at a wide range of pH, *viz.*, 4·0 to 10·5. Its apparent similarity in cultural and growth characteristics to some common bacteria suggested that the latter might also be endowed with capacity of solubilisation of phosphates.

The present report deals with solubilisation of phosphates by *B. subtilis*, *B. megatharium*, *B. mesentericus* and *B. mycoides* as well as by Fosfo 24 in Kisch's basal glucose salt solution (Kisch, 1919) whose pH had been adjusted to 7·0 and where the phosphates had been replaced by 1 g. per 100 c.c. each of different insoluble phosphates and with 0·5 g. each of ammonium sulphate or urea as nitrogen source. The culture liquids were centrifuged after incubation for two months at 30° C. and water-soluble phosphates determined in the clear liquids by the usual methods.

In presence of ammonium sulphate the organisms brought into solution from 4·36 (Fosfo 24) to 9·65 (*B. subtilis*) per cent. of P_2O_5 contained in calcium phosphate, from 0·77 (*B. mycoides*) to 2·07 (Fosfo 24) per cent. in ferric phosphate, from 3·62 (Fosfo 24) to 10·82 (*B. subtilis*) per cent. in calcium glycerophosphate and from 5·10 (Fosfo 24) to 21·23 (*B. mycoides*) per cent. in lecithin. The amount of P_2O_5 solubilised from Trichi nodules and Singbhum phosphate were small. *B. mesentericus* and *B. mycoides* failed to solubilise any P_2O_5 contained in bonemeal; rather they utilised some P_2O_5 already soluble. 14·22% of P_2O_5 contained in bone-meal was solubilised by Fosfo 24.

In presence of urea, *B. subtilis* decreased the amount of P_2O_5 already soluble in calcium phosphate; the rest solubilised P_2O_5 in amounts ranging from 3·29 (Fosfo 24) to 6·51 (*B. mycoides*) per cent. The same tendency was observed in the case of ferric phosphate. The quantities of P_2O_5 brought into solution ranged from 4·79 (*B. mycoides*) to 7·10 (Fosfo 24) per cent. The organisms solubilised very little P_2O_5 from bone-meal, Trichi nodules and Singhbum phosphate. *B. megatharium* solubilised 13·19% and Fosfo 24, 10·88% of P_2O_5 contained in calcium glycerophosphate. From lecithin, solubilisation of P_2O_5 was observed in the case of Fosfo 24 (15·65%) and *B. megatharium* (17·59%); rest of the organisms utilised large portions of soluble P_2O_5 already present in the material.

It would appear from above that some common soil bacteria have also the property of bringing phosphorus from insoluble phosphates into solution like the phosphorbacteria, though organisms like *B. subtilis* may, in presence of urea, utilise largely whatever phosphorus is already available in calcium phosphate, ferric phosphate and lecithin rather than bring into solution fresh phosphorus in appreciable amounts.

Our grateful thanks are due to Dr. S. R. Sen of the Ministry of Agriculture for kindly obtaining for us the strain of Phosphorobacterium from Czechoslovakia. Our thanks are also due to Dr. B. P. Pal, Director, I.A.R.I., for kind permission to publish this note.

Indian Agric. Res. Inst., ABHISWAR SEN.
New Delhi, *May* 22, 1957. N. B. PAUL.

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REVIEWS

High Speed Diesel Engines. By A. W. Judge. (Chapman & Hall, Ltd.), 1957. Pp. vii + 578. Price 65 *sh.*

This is the fifth edition of the popular book, *High Speed Diesel Engines*, by A. W. Judge, bringing its scope and contents in line with current developments. In a rapidly expanding scientific field like Internal Combustion Engines, considerable variations in the type of approach and technical level of treatment are possible in presenting the engineering information, analytical treatment and descriptive details of speciality equipment of manufacturers. The author's approach is admirably suited for the student, engineer, draughtsman and engine operator for whom the book is mainly intended. The book represents a summarisation and integration of a vast amount of engineering knowledge on the current state of development and practice in the High Speed Diesel Engines and their applications in various fields.

The opening chapter commences with a survey of the history and development of the diesel and compression ignition engines, leading to the present highly developed form of high speed compression ignition engines—more popularly called as "High Speed Diesel Engines". Following this, the fundamental principles of I. C. Engine and its features like engine cycles, combustion, thermodynamic performance and efficiency are dealt with. A comprehensive survey of fuel injection equipment, combustion chambers, combustion processes, etc., are next discussed in a manner that will specially appeal to junior engineers. A full chapter is devoted to supercharging with descriptive details of superchargers of leading manufacturers. Separate chapters deal with two-stroke engines, stationery engines, air-cooled engines, small passenger vehicle engines and commercial vehicle engines. The versatility of the high speed diesel in its applications is significantly brought forth in a chapter on special purpose engines and a number of individual makes of engines are discussed for road and rail transport, diesel electric traction, marine engines, submarines, aircrafts, etc. The last three chapters are devoted to the subjects of starting of the engines, filters for air and fuel and special characteristics of fuels.

The book is eminently suited as a standard text-book for the upper division course in technical high schools and should be welcomed by students and engineers having to deal with the production or operation of high speed diesel engines.

A. V. NATH.

The Manufacture of Iron and Steel. Vol. I. By G. Reginald Basforth, F.I.M. (Chapman & Hall, Ltd.), 1957. Pp. xii + 306. Price 45 *sh.* net.

The second edition of the book is an excellent addition to others on the metallurgy of iron and steel and a distinct improvement on its first edition.

Written by an expert in the production metallurgy of iron and steel, this book is an ideal text-book for the general student on the subject. To the industrialist, it provides adequate latest references on diverse aspects of iron metallurgy and blast furnace operations. To the engineer its importance is obvious in presenting an assimilable account of complicated physico-chemical reactions involved in the production metallurgy of iron. The book represents a typical British attitude on teaching metallurgy—a painstaking effort to combine theory with practice. As one runs through the book, he finds the optimum balance—thermodynamics of chemical reactions on the one hand to the actual steel plants layout on the other. To have attained this in a book of 300 pages is a remarkable achievement. Another praiseworthy feature of the book is the appendages of "recent research and developments" at the end of each chapter.

The book starts with the classification of iron ores, their geographical distribution and their evaluation. In this connection, however, it is pointed out that the book sadly lacks a broad-based world outlook in respect of iron ore resources and classifications, other raw materials and metallurgical practices. In case of India, *e.g.*, reference is made of Mysore iron ores and of its magnetites; there is, however, no mention of classic hæmatite iron ores of Bihar and Orissa. In the iron ore belts of Bihar and Orissa, discovered at the turn of the present century, lie probably the richest and largest iron ore deposits of world surpassing in magnitude even the Lake Superior ores which are now nearing exhaustion. These Indian iron ore

reserves reckoned at over 8,000 million tons are a world envy. The book dwells far too disproportionately upon British resources of iron ores and other raw materials which are by any standards meagre, than its title warrants. The world iron ores and connected raw material reserves and resources are now being well detailed in United Nation's publications of surveys of world's raw materials which could have advantageously been profusely referred to so that the book attracts attention outside the shores of Britain. This is not to say, distracting from the intrinsic worth of the publication but the comment is made with the hope that in the third edition of the book these gaps will be bridged to meet the requirements of the readers in countries other than Britain. Mention may also be made of printer's devil here and there such as relating to references on page 258 and their mix up in the text starting from Nos. 13 to 18. These can be readily rectified now through the issue of an "erratum". On page 257 the last para needs slight changes. Mention could also have been made on page 256 that at Mysore, the latest Tysland-Hole electric pig iron smelting furnace is in operation relegating the charcoal furnace very much to the background.

In the chapter on iron ores, useful reference has been made on the use of sinter in the iron blast furnace. Not all blast furnaces of the world operate on sinter burden whilst many operate on 100% sinter charge. Perhaps, a reference to Russian blast furnace practice operating more or less invariably on iron sinter burden resulting in very much increased productivity and reduced fuel costs would not have been quite out of place even though no reference has otherwise been at all made to Russian raw materials and practices despite the recent tide of interest shown by British team of metallurgists visiting Soviet Union and commenting upon Russian iron and steel technology. Perhaps, it may also be mentioned that some figures like that of magnetic separator on page 45, old beehive coke oven no longer widely used these days could be safely substituted by due references to latest assessment, raw materials situation and research and plant developments in parts of the world other than the U.K. It is hoped that these comments will be taken in the spirit in which they are made, that is, with a view to further widen the range of readers in different parts of the world for this otherwise undoubtedly excellent addition to the texts on iron and steel metallurgy, lucidly written, neatly printed and well bound for which the author is to be warmly congratulated.

It is also greatly heartening to note the references made to low shaft iron production and manufacture of ferro-alloys—subjects currently of great interest to India in the background of our Second Five-Year Plan wherein determined efforts are being made to set up ferro-alloy manufacture and low shaft furnace iron production methods.

B. R. NIJHAWAN.

The General Theory of Electrical Machines. By B. Adkins. (One of the Advanced Engineering Text-Book Series.) (Chapman & Hall, Ltd., London), 1957. Pp. ix + 236. Price 45 *sh.*

The book presents a general theory of rotating electrical machines applicable to all the normal types of machines and to all conditions of operation. Thus the theory is more fundamental and is of wider application than the usual theories given in the standard text-books on electrical machines.

Though there has been developments both in the concepts for different types of machines as also in the theory explaining the characteristics of operation of the machines, in the past, each type of machine has been dealt with on its own merits without much reference to other types and simple methods of analysis have been developed by means of which the performance under specified conditions can be calculated. The methods, thus, have been piecemeal and have the disadvantage that completely fresh start has to be made when it is necessary to analyse a new type of machine or to deal with unbalanced or transient conditions.

Gabrial Kron's visualisation that all electric machines may be considered from the point of view of electromagnetic field problems and his application of tensorial methods to their analysis as a group have led to the new line of thought in modern theory of electric machines. In the modern theory, algebraic equations are accepted as the fundamental means of expression. In line with recent developments in circuit theory, the use of equations leads to a general theory of all electrical machines which embraces all types and all conditions of operations. It may be noted, however, that while matrix methods are often extremely useful for organising the algebraic and other experimental work and tensors are of great value for more advanced investigations, both these should be regarded as mathematical tools applied to a fundamental concept which can be completely, although less elegantly, expressed in terms of ordinary algebra. The author has very ably demonstrated this in the book under review.

In the first ten chapters, matrix notation is used only for the purpose of setting out the equations in an orderly manner. The manipulation of the equations is, however, carried out by ordinary algebraic method.

The author, after referring to Blondel's "two-reaction theory" of the steady state operation of the salient pole synchronous machines and West's "cross-field theory of alternating current machines", has indicated how Park's transformation provides the most important fundamental concept in the development of Kron's generalised theory.

In the first ten chapters, consisting of introduction, D.C. machines and A.C. machines, the general equations are derived and used to demonstrate the wide range of application for solving practical problems.

In the last chapter a statement of the generalised theory is given in matrix notation, and some of the simpler methods of matrix algebra is explained.

The Heaviside method has been used throughout the book as in the author's view it is advantageous to use the Heaviside notations for the general equations of machines because of the fact that they are non-linear. According to the author, the Laplace transform notation is suitable for the study of circuits and control systems because, for the subjects, the equations used in developing the basic theory are linear.

A chronological bibliography gives all references to assist the reader pursue the matter further. A good deal of attention has been given to the development of approximate methods and to the use of analyzers and computing devices.

The author is to be commended for the timely presentation of such a book when a co-ordinated and unified method of approach is very much needed to provide a more powerful line of attack on new problems.

The book will be very useful to students and designers as a basis for the understanding of the modern unified approach to the generalised electrical machine theory.

C. S. G.

Crystal Structures. Vol. II. Chapters XI and XII. By Ralph W. G. Wyckoff. (Interscience Publishers, Inc., New York), 1957. Price $ 7.00.

The first instalment of the book, *Crystal Structures*, by Dr. R. W. G. Wyckoff, appeared in 1948 in loose leaf form printed in imitation typescript and comprised of Chapters I to VII under Section I. Crystallographic data and atomic parameters for a large number of inorganic structures were discussed in the section and the substances were classified according to their chemical formulæ. Tentative contents of Section II and Section III that were to follow had also been indicated in it. Supplement and replacement sheets to bring the material up-to-date were also promised in the publisher's note attached. Several of these have appeared since then. The plan of the book has slightly been altered and the whole of the material is presented in three volumes: Volume I comprising of Chapters I to VII (1948), Volume II, Chapters VIII to XII (Chapters VIII to X and XIII, 1951) and Volume III, Chapters XIII to XV with an index to organic compounds attached to it (1953).

The matter under review forms part of Volume II and consists of Chapters XI and XII. Chapter XI bears the title, "Miscellaneous Inorganic Compounds", and presents structural data and atomic parameters for some complex and basic halides thio salts, complex sulfides, complex oxides and for three other miscellaneous compounds. Chapter XII under the heading, "Structure of the Silicates", concerns itself with a large number of silicates under four major groupings: Discrete silicate groups, silicate chain structures, silicate sheet structures and network silicates. The discrete silicate group is further subdivided into orthosilicates, pyrosilicates and more complex SiO groups.

With the addition of a large number of silicate structures, the publication will interest a much wider group of investigators in the field of mineralogy and structural chemistry. The great advantage of the new method of publication adopted here is the collection of information for a particular substance in one place. Continuous numbering of pages has not been practicable, but one should experience no difficulty in locating a particular compound after going through the instructions. However, an alphabetical index of compounds would be a welcome addition. Each chapter consists of a text portion, tables and illustrations (illustrations to follow). A bibliography commencing from 1931 up to 1955 is given at the end of each chapter.

The whole collection is well worth having as a reference book and will be of interest to all those who in one way or another are concerned with the crystalline state.

A. JAYARAMAN.

Antibiotics Annual, 1956-57. Edited by Henry Welch, Ph.D. and Felix Marti-Ibanez, M.D. (Medical Encyclopædia, Inc., New York, N.Y.), 1957. Pp. xviii + 1134. Price $ 10.00.

This fourth successive volume gives an account of the Proceedings of the Fourth Annual Symposium on Antibiotics held on October 17, 18 and 19, 1956, in Washington, D.C. It contains 154 papers and an account of three panel discussions on "Antibiotics and Intestinal Antiseptics", "Susceptibility of Micro-organisms to Antibiotics Isolated from Hospitalised and Non-Hospitalised Persons" and "Present Status of Antibiotics in the Preservation of Food". As stated by Dr. Welch, "these Annual Symposiums on Antibiotics have become an important forum in which the progress, failures and new trends are initiated in a worldwide interchange of ideas". The collection of papers, particularly in a single volume, "constitutes a complete story for those interested in appraising their past year's advance and accomplishments and hopes for the future".

Workers in USA certainly unearth for more number of antibiotics than those anywhere else. The output of work on antibiotics is also much more in USA than anywhere else. Consequently, the papers are mostly from USA. There are contributions from nine other countries, but one wishes that more countries take part in this Symposium, much more actively than at present. The work reported is concerned with the antibiotics: oleandromycin, vancomycin, amphotericin B (an antifungal antibiotic), arcosin, nystatin, novobiocin, ristocetin, synnematin B, hygromycin, xanthocillin, penicillin V, etc. The search for synergistic and additive combinations of antibiotics is actively going on. But not all, including some authorities in the subject, will share the enthusiasm of Dr. Welch about the combinations that it heralds a new era of antibiotic therapy. One has to guard against this being capitalised as a commercial selling point to put in the market all sorts of combinations of dubious value, descending to the level of proprietary medicines. Oleandromycin, neomycin and nystatin show the polyandrous tendency as regards the combinations. The use of antibiotics, particularly chlortetracycline and oxytetracycline, as good preservatives, is being investigated to put a stop to the 25% of the spoilage now taking place in food products even in USA.

Marti-Ibanez in his characteristic philosophical way adds a thought-provoking article on problems of medical communications. It is not well appreciated that for the effective application of the antibiotics, not only do we need the antibiotics but also the doctors fully posted with the most accurate knowledge about these potent weapons. In view of this, the reviewer hopes that the commendable wish of Marti-Ibanez "to bring out at the *earliest* possible date, to as *many* people as possible, the *greatest* possible number of the *best* possible medical work" will not remain Utopian but becomes a reality at the *earliest* possible date.

K. GANAPATHI.

UHF Tubes for Communication and Measuring Equipment. (Compiled by Members of Philips Electric Tube Division, Philips Technical Library), 1956. Pp. 70. Price Rs. 5.

Tube Selection Guide, 1956-57. Compiled by Th. J. Kroes. (Philips Technical Library), 1956. Pp. 124. Price Rs. 5.

One of the significant developments in electronics circuitry in the post-war era is the rapid opening up of the centimetric and millimetric wave region and the increasing applications of such waves in the fields of television, radar, and other public services. The first book under review describes in some detail the tubes that can be used in this frequency range. To reduce the transit-time effects, the interelectrode distances are to be drastically shortened and it is interesting to see how this has been achieved in tubes such as EC 80, EC 81, K 81 A and DC 70. At frequencies above 500 Mc/s. disc-seal triodes (EC 55, EC 56 and EC 57) in which the concentric electrodes are replaced by flat equidistant electrodes are employed. Transit-time effects are taken advantage of in designing velocity modulation tubes and two reflex klystrons 2 K 25 and 723 A/B suitable for use in the 3 cm. band are described. Finally, for the computation of the noise figures of receivers, the use of K 81 A (for metric waves) and the gas discharge tubes K 50 A and K 15 A (for the 3 cm. and 10 cm. bands respectively) is detailed.

In the conventional RF and AF regions, there is such a variety of tube types that the experimenter is often baffled to select the right type for the application in any particular case and further to assess the equivalence of one type with another in case of replacements. The second book under review is handy for this purpose since it includes: (*i*) Tables of all tubes manufactured by Philips or those for which Philips have an equivalent, (*ii*) Tables in which the tubes are grouped according to their functions, (*iii*) Preferred tube types, (*iv*) Replacement tube types, (*v*) Replacement

of obsolete tubes, (*vi*) RETMA and continental systems of tube designation and data on tube bases and tube holders.

Tube manuals have become such an integral part of any laboratory in electronic circuitry that the publication of these two books by the well-known manufacturing company of Philips will be welcomed.

RAM K. VEPA.

Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Vol. 5.—*Physics of Reactor Design*. (United Nations Publication, New York), 1956. Pp. viii + 545. Price $ 9.00.

This is the fifth volume of the series which report the Proceedings of the International Conference held in Geneva in August 1955, on the peaceful uses of atomic energy. The volume is divided into five sections dealing with interglobal experiments important to the design of reactor, such as exponential and critical experiments as well as resonance integrals and kinetic measurements.

The first section, on integral measurements, includes mainly the determinations of diffusion and slowing down areas in the moderators using the static and pulsed techniques. An interesting review of theoretical and experimental work on slowing down in hydrogenous media is included by Wilkins *et al.* (USA).

The second section reports measurements of resonance integral, long-term changes and criticality of solutions of fissile materials. The third section deals with zero energy and exponential experiments with excellent reviews of D_2O-uranium and graphite-uranium lattices. The discrepancy between the different experimental results performed with D_2O-uranium lattices is underlined by Cohen. This section will prove of great use to the reactor physicist.

The fourth section includes three papers covering the fast reactor experimental studies and five theoretical papers on reactor kinetics and control problems.

The fifth section is devoted to papers on reactor theory. These provide a useful discussion of theoretical techniques of particular interest in predicting the critical size of assemblies of a small number of fuel elements. A survey paper on neutron thermalization theories by Cohen is also included. The lack of experimental information of neutron thermalization in Be, C and Be O reflects the smaller number of investigations in this field. Also included in this section are the spherical harmonics method for fine-structure flux distributions and Milne's problem.

It is, for the reactor physicist, an essential reference book.

V. P. DUGGAL.

Rice in Orissa. (Department of Agriculture, Orissa), 1956. Pp. 121, 11 grs., 34 plates. Price Rs. 7.

Rice is the most important single crop in Orissa. The book under notice which is a compilation of contributions by G. V. Chalam and others is an account of the activities of the Orissa Agricultural Department during the past 20 years since Orissa was constituted into a separate province. Work on rice has been carried out in the three research stations, Cuttack, Berhampore and Jeypore. The first two were started as substations of Sabour and Coimbatore and rice research in Orissa Province is a continuation of the work previously conducted under the control of the paddy specialists of the old provinces of Bihar and Madras, respectively. Cuttack has, in recent years, been taken over for locating the Central Rice Research Institute and the provincial research station has been shifted to Bhubaneshwar.

The book has six chapters, dealing with the general background, botanical research including breeding and physiology, agronomical research, pests and diseases, improved varieties and marketing. The rice research scheme has been in progress only for a comparatively short period and hence little work has been carried out by the way of hybridisation. The hybrids handed over by the Madras Agricultural Department at the time of partition have been carried to further generations and studied. Pure lines which are higher yielding are under study. The Department is obtaining the F_2 seeds of *japonica* × *indica* crosses effected by the Central Rice Research Institute under the auspices of the FAO. These are being studied with a view to selecting types to fulfil objectives of low height, heavy tillering, response to fertilisers, etc.

Orissa is a land of rivers and intermittent floods are common. The coastal areas are also subject to flooding by sea-water and many of the lands are saline. While flood- and salinity-resistant types are needed for the coastal plains, for the upland areas drought-resistant types are required. The evolution of these has claimed the attention of the breeder and the physiologist. Flood- and drought-resistance have been sought to be induced by presprouting treatments; correlations have also been attempted to be worked out between resistance and anatomical features. Seeds of spring rices are reported to lose their viability when sown

in the following spring and efforts have been made to prolong their viability and, in the alternative, to break the dormancy of winter rices to enable them to be grown in spring. Study of micro-nutrient nutrition is a feature of agronomical investigations. The chapter on marketing reveals the fact that the co-operative movement is yet to find its place in the marketing of rice in Orissa.

The book presents the appreciable progress made in the brief period of work of the Department. The few words of criticism that follow are intended to help the authors to bring out a better edition free from avoidable defects. There is room for improvement in the arrangement of matter under headings. The studies on shattering and the nature of open and compact panicles are reported under the heading 'Drought Resistance' (p. 55). According to Parija (1938) (cited by Ramiah and Rao), the immediate objective of the treatments in the experiments to induce flood resistance was to 'educate' the sprouting plants to insufficiency of light and oxygen. This method of approach could have been explained by the present authors as they are apparently reporting the same or similar experiments. The use of the term 'vernalisation practice' to denote a procedure whose objective is not shortening the vegetative phase but inducing flood-resistance, does not appear to be appropriate. Techniques used could, with advantage, have been described in more adequate detail. It is somewhat confusing to read that there is no response to potash, and immediately thereafter to find that the best manurial combination is 45 lb. N, 40 lb. P_2O_5 and 30 lb. K_2O (p. 69). Vague terms and phrases which do not correctly convey the meaning intended are distressingly common, *e.g.*, 'flood resisting selection' (p. 30); 'a week days earlier' (p. 31); 'nature of applying' (p. 60); 'the usage of edible cakes' (p. 62); 'There is no effect of liming' (p. 69). The bibliography is sketchy and by no means complete. For instance, work on salinity-resistance has been carried out by workers in Orissa for a number of years, but their reports do not find a place in the bibliography and a note that appeared in 1954 has been cited as the sole reference.

The book has many excellent photographs, bearing on the subject of rice in Orissa. The printers deserve much credit for the very attractive get-up; with such meticulous care given to the quality of the production, one wishes that the nine-line errata had not been necessary.

N. L. DUTT.

Books Received

Aircraft Hydraulics, Vol. I. Second Edition. By Noel L. Allport and J. W. Keyser. (Chapman & Hall), 1957. Pp. xi + 424. Price 50 *sh.*

Gas Dynamics. By Klaus Oswatitsch. English version by G. Kuerti. (Academic Press, Inc.), 1956. Pp. xv + 610. Price $ 12.00.

Momentum Transfer in Fluids. By H. Corcoran, J. B. Opfell and B. H. Sage. (Academic Press, Inc.), 1956. Pp. xi + 394. Price $ 9.00.

Fatigue in Aircraft Structures. Edited by Alfred M. Freudenthal. (Academic Press, Inc.), 1956. Pp. xiii + 456. Price $ 12.00.

Brookhaven Symposia in Biology, No. 9. *Genetics in Plant Breeding*. (Biology Department, Brookhaven National Laboratory, Upton, New York), 1956. Pp. ix + 236. Price $ 1.25.

The Defect Solid State. By T. J. Gray and others. (Interscience Pub.), 1957. Pp. viii + 511. Price $ 11.00.

Earthquakes in the Himalayan Region. By S. K. Banerji. (Indian Association for the Cultivation of Science, Calcutta-32), 1957. Pp. 64. Price Rs. 3.

Mitchondria and Other Cytoplasmic Inclusions. Edited by F. K. Sanders. (Society of Experimental Biology Symposia No. 10.) (Cambridge University Press, London, N.W. 1), 1957. Pp. 198. Price 55 *sh.*

Hormones, Brain Function and Behaviour. Edited by Hudson Hoagland. (Academic Press, New York), 1957. Pp. 257. Price $ 7.00.

Carnegie Institution of Washington Year-Book, 1955-56. (Carnegie Institute of Washington, 1530, P. Street, Washington-5, D.C.) Pp. 343. Price $ 1.00.

The Indian Ephemeris and Nautical Almanac for the Year 1958. (Director, Regional Met. Centre, Alipore, Calcutta-27.) Pp. xviii + 392. Price Rs. 12.

Problems in Nuclear Engineering, Vol. I. Edited by D. J. Hughes, S. Mclain and C. Williams. (Pergamon Press, New York), 1957. Pp. ix + 365. Price £ 6.0.

Reactor Operational Problems, Vol. II. Edited by D. J. Hughes, S. Mclain and C. Williams. (Pergamon Press, New York), 1957. Pp. vii + 278. Price £ 6.

The Hypercircle in Mathematical Physics. By J. L. Synge. (Cambridge University Press, London, N.W. 1), 1957. Pp. xii + 424. Price 70 *sh.*

Introduction to Printed Circuits. By Robert L. Swiggett. (Chapman & Hall, London, W.C. 2), 1957. Pp. vii + 101. Price $ 2.70.

SCIENCE NOTES AND NEWS

***Aldrovanda vesiculosa* Linn. from Manipur**

Dr. D. B. Deb, Dept. of Botany, M. B. B. College, Agartala (Tripura), records the discovery of *Aldrovanda vesiculosa* Linn. from Manipur from the College Reserve Tank, Imphal, on 2nd August, 1953, and subsequently from other tanks and colonies in association with *Utricularia flexuosa* Linn., *Mariscus cyperiodies* and other grasses. After this the plant did not grow again in these places so far. Thus the writer opines that the seeds remain viable for a long period and germinate only on favourable edaphic conditions at a particular period of the year. In this connection the author quotes a reference to an article in *Sci. & Cult.*, 1937, 3, 47, by Sengupta wherein an attempt has been made to explain why the plant remained undetected for seventy long years.

Brighter Phosphor Blends for Television Picture Tubes

New blends of phosphors, with greatly increased brightness, have been perfected by the Du Pont Company. Designed for use in television picture tubes, the new light-body colour types are available in special blends suitable for black or aluminized tubes, and in different formulations adapted for either the flotation or spray filming techniques.

During rigid tests and field evaluations by tube manufacturers in the United States, the new phosphors have shown excellent adhesion characteristics, increased efficiency of light emission, improved body colour, and adaptability to the manufacturing techniques of individual tube manufacturers. The new phosphors are blended to provide the emission colour specified by the purchaser.

For further information write to: John A. Laberee, Du Pont Information Service, 1064, Du Pont Building, Wilmington, Delaware, U.S.A.

Colonel Amir Chand Trust Prizes for Medical Research

The Governing Body of the Indian Council of Medical Research has constituted a Trust called the "Colonel Amir Chand Trust" from a donation of Rs. 50,000 received from Lieut.-Colonel Amir Chand for the purpose of awarding prizes for the best published research work in the field of medical sciences.

The Council has decided to award during 1957 four junior prizes of the value of Rs. 300 each, for graduates of not more than ten years' standing, for the best research papers in medical sciences in general (including clinical research) published during the calendar year 1956.

Candidates are required to submit their applications along with 10 reprints of their papers published during 1956, to the Director, Indian Council of Medical Research, P.O. Box 494, New Delhi, so as to reach him not later than the 1st August 1957.

Raptakos Medical Research Fellowships

The Raptakos Medical Research Board will consider applications for the award of fellowships, which commences from January 1958, for research work on medical and allied subjects in recognised institutions situated in the Union of India.

The awards normally consist of Rs. 3,000 per year for a Fellowship and Rs. 750 per year towards special equipments or chemicals approved by the Board.

Applications in the prescribed form (which may be obtained from Secretary and Treasurer, Raptakos Medical Research Board, Dr. Annie Besant Road, Worli, Bombay-18), should be submitted before September 30, 1957.

Third International Team Work on Embryology

The Hubrecht Laboratory organises projects for international research teams every two years. The third team will meet in 1958 from March 15th till September 15th. The general idea of international co-operation in science as well as specific scientific aims will be served by these projects.

The general topic for 1958 will be "A Morphological and Physiological Analysis of Regulative and Non-Regulative Processes in the Development of 'Mosaic' Eggs of Several Terrestrial and Fresh-water Invertebrates".

This team will be under the personal direction of Prof. Dr. Chr. P. Raven, Zoological Institute, University of Utrecht, and of Dr. P. D. Nieuwkoop, Hubrecht Laboratory, Utrecht.

The team is open to post-graduates in biology and related sciences and is particularly meant for young staff members who will be able to continue their work afterwards.

Those interested should write to the Director of the Hubrecht Laboratory as soon as possible, including information about their scientific education and personal record.

Third Congress on Theoretical and Applied Mechanics

The Third Congress on Theoretical and Applied Mechanics will be held at the Indian Institute of Science, Bangalore, from December 24-26, 1957, under the Presidentship of Dr. S. R. Sen Gupta, Director, Indian Institute of Technology, Kharagpur.

Research papers to the Congress will cover the following topics:

1. Elasticity, Plasticity, Rheology.
2. Fluid Mechanics (Aerodynamics, Hydrodynamics).
3. Mechanics of Solids (Ballistics, Vibrations, Friction, Lubrication).
4. Statistical Mechanics, Thermodynamics, Heat Transfer.
5. Mathematics of Physics and Mechanics, Methods of Computation.

Further information regarding the Congress can be had from the Secretary-Treasurer (Dr. B. R. Seth), Indian Institute of Technology, Kharagpur.

The Zoological Society of India

The new Executive Council of the Society has been elected as follows: *President*: Dr. M. L. Roonwal; *Vice-Presidents*: Dr. H. S. Rao, Dr. G. S. Thapar; *Editor*: Prof. R. V. Seshaiya; *Secretary*: Prof. P. N. Ganapati; *Treasurer*: Dr. B. S. Chauhan; *Manager of Publications*: Shri K. Chidambaram; *Members*: Dr. N. K. Panikkar, Dr. B. N. Chopra, Dr. B. Prashad, Dr. M. A. Moghe, Dr. J. L. Bhaduri and Dr. H. N. Ray.

The Indian Zoological Memoirs

The Zoological Society of India has unde taken, in agreement with late Prof. K. N. Ba to reprint or publish revised editions of t eight Memoirs which were edited and publish by late Dr. Bahl. Authors having manuscrip for publication as new Memoirs under t series may contact the Editor, Secretary Treasurer of the Society in this connection.

Dr. B. R. Seth

Dr. B. R. Seth, of the Indian Institute Technology, Kharagpur, is proceeding abroad a lecture-*cum*-conference tour. He has be invited by the University of Alexandria, t Polish Academy of Sciences, the Soviet Ac demy of Sciences, and the International Uni of Theoretical and Applied Mechanics to gi lectures and to take part in symposia and co ferences on 'Elasticity and Plasticity' a 'Boundary Layer Research'.

Award of Research Degree

The Andhra University has awarded t D.Sc. Degree in Technology to Shri M. Ra Rao, for his thesis entitled, "Studies on Ma Transfer in Wetted Wall and Packed Extra tion Towers and Ternary Liquid Equilibria".

The Annamalai University has awarded t Ph.D. Degree in Chemistry to Sri. Sp. Sha muganathan for his thesis entitled, "A Physic Chemical Study of Sulphur-Oxygen Bond a Conjugation in Sulphones".

The University of Poona has awarded t Ph.D. Degree in Botany to Shri Ishver Narottamdas Solanky, for his thesis entitle "Embryological Studies on Family Chen podiaceæ".

NOTICE

THE Editorial Office which was temporarily located at Madras-25 has now been transferred to Bangalore permanently.

All material intended for publication in *Current Science*, corrected proofs, books for review and exchange journals may, therefore, be sent to the following address hereafter:

The Editor, *Current Science*,
Malleswaram P.O., Bangalore-3.

Remittances, correspondence regarding subscriptions to the Journal, advertisements, etc., may please be addressed as usual to:

The Manager, Current Science Association,
Malleswaram P.O., Bangalore-3.

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